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TAXONOMY AND ECOLOGY OF STENONEMA MAYFLIES (HEPTAGENIIDAE:EPHEMEROPTERA)

Philip A. Lewis

National Environmental Research Center
Cincinnati, Ohio

December 1974

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This manual provides keys and descriptions of all North American species of Stenonema mayflies and consolidates information from the literature on their ecology, environmental requirements, and pollution tolerance. Accounts of each species include synonymy, nymphal description, collection records, and a distribution map. The 31 species described and keyed include three recently described species, four new synonyms, two resurrected species, and new combinations involving three additional species and subspecies. Twelve species and one subspecies are classified as intolerant to organic pollution, eight species as tolerant of mild pollution, and seven species and two subspecies as tolerant to moderate pollution.

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TAXONOMY AND ECOLOGY OF *STENONEMA* MAYFLIES

(HEPTAGENIIDAE:EPHEMEROPTERA)

by
Philip A. Lewis, Aquatic Biologist
Methods Development and Quality Assurance
Research Laboratory
National Environmental Research Center
Cincinnati, Ohio 45268

NATIONAL ENVIRONMENTAL RESEARCH CENTER
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CINCINNATI, OHIO 45268

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FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment — air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

The effectiveness of measures taken to protect the biological integrity of the Nation's surface waters is dependent upon our knowledge of the environmental requirements of aquatic organisms and our understanding of the complex relationships that prevail in aquatic ecosystems. Mayflies are important components of the aquatic food web and are useful water quality indicator organisms. This manual contains a summary of available information on the pollution tolerance of one genus of these organisms and improved keys for their identification. It was developed to assist biologists in evaluating data collected during studies concerning the effects of pollutants on the structure of indigenous communities of aquatic organisms.

A. W. Breidenbach, Ph.D.
Director
National Environmental
Research Center, Cincinnati

ABSTRACT

This manual provides keys and descriptions of all North American species of *Stenonema* mayflies and consolidates information from the literature on their ecology, environmental requirements, and pollution tolerance. Accounts of each species include synonymy, nymphal description, collection records, and a distribution map. The 31 species described and keyed include three new species, four new synonyms, two resurrected species, and new combinations involving three additional species and subspecies.

Twelve species and one subspecies are classified as intolerant to organic pollution, eight species as tolerant of mild pollution, and seven species and two subspecies as tolerant to moderate pollution.

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William T. Mason, Jr., Benthos Group Leader and Dr. Cornelius I. Weber, Chief, Biological Methods, of this office, offered many valuable suggestions and encouragement during development of this manual.

INTRODUCTION

The potential usefulness of species of *Stenonema* mayflies as indicators of water quality has been recognized by many pollution biologists (Cairns et al., 1973) but has been largely unexploited in enforcement and long-term water quality studies, because the poor state of the taxonomy of the genus prevented reliable identification of the nymphs to the species level, and information on the ecology and pollution tolerance of the species was lacking or was widely scattered in the technical literature and generally unavailable to practicing water pollution biologists.

Although mayflies as a group are generally considered pollution sensitive, we have observed that species of *Stenonema* vary widely in their tolerance to pollution (Lewis, 1973). If identifications are not carried to the species level, therefore, the use of indicator organism techniques may lead to erroneous conclusions about the quality of the water from which the samples are collected.

This manual was prepared to provide EPA and other aquatic biologists with updated and improved keys and descriptions of the species in this genus and to consolidate available information on their ecology, environmental requirements, and pollution tolerance, which are needed to identify the organisms and evaluate data collected during water quality studies.

During the course of this project, approximately 500 adults (imagos) and 1,000 nymphs were collected from streams throughout the Ohio River Basin (Fig. 1). Approximately 300 imagos were reared from nymphs by the author. The author also examined various collections containing approximately 5,000 specimens of *Stenonema* nymphs and imagos, including most of the type series for the 31 species included in this manual. Dr. Burks' collection at the Illinois Natural History Survey and Dr. Traver's collection at Cornell University Museum were obtained for detailed examination and photography. The author visited the Entomological Research Institute of Canada, Ottawa, and the Museum of Comparative Zoology at Harvard University to examine the collections of Drs. Clemens, McDunnough, Banks, and Walsh. Where necessary, specimens were taken from these collections to our laboratory for additional study. A summary of the 1,267 specimens examined in detail from both private and public collections is presented in Appendix B.

Many of the collections examined were of limited value in checking the original descriptions because the colors had faded from alcohol-preserved specimens, the forelegs were missing from many pinned specimens, and the genitalia were missing from some of the type specimens. Few collections contained sufficient reared material to form a series for comparative purposes. These collections were invaluable, however, as an aid in selecting valid taxonomic characters. Most of the characters used in constructing the keys in this manual were checked against the available type specimens or against specimens for which the identity had been confirmed by another Ephemeroptera specialist.

To provide a unified picture of the genus, all of the known species of *Stenonema* were included in this manual, however, the major emphasis was placed on those species from the Ohio River Basin.

Information on the ecology, pollution tolerance, and distribution of *Stenonema* presented in this manual was taken from the published literature, the author's field notes, and water quality studies conducted by USEPA aquatic biologists.

METHODS

Adults were collected during the day by picking or sweeping from vegetation, and at night from vegetation, buildings near street lights, lighted windows of cottages, and auto headlights near streams. A white sheet held in front of the headlight aided in attracting the mayflies. In order to obtain imagos, the subimagos were placed in 10 dram vials fitted with cheesecloth tops and stored in a moist place until the subimaginal skins were shed. Nymphs were collected by hand picking, dip net, Surber sampler (Surber, 1936), or basket sampler (Mason et al., 1973), depending on stream conditions.

The most valuable specimens for taxonomic work are those reared from nymphs because the imago and subimago can be positively associated with the nymphal exuvia. Nymphs were transported to the laboratory and reared in plastic shoe boxes on a gravity flow rearing apparatus (Mason & Lewis, 1970). Water temperature was maintained below 30°C during transportation and rearing. Several rocks placed in the bottom of the tanks provided shelter for the nymphs. Cast skins of the nymph and subimago were preserved in the same vial as the reared adult to reduce the possibility of incorrect

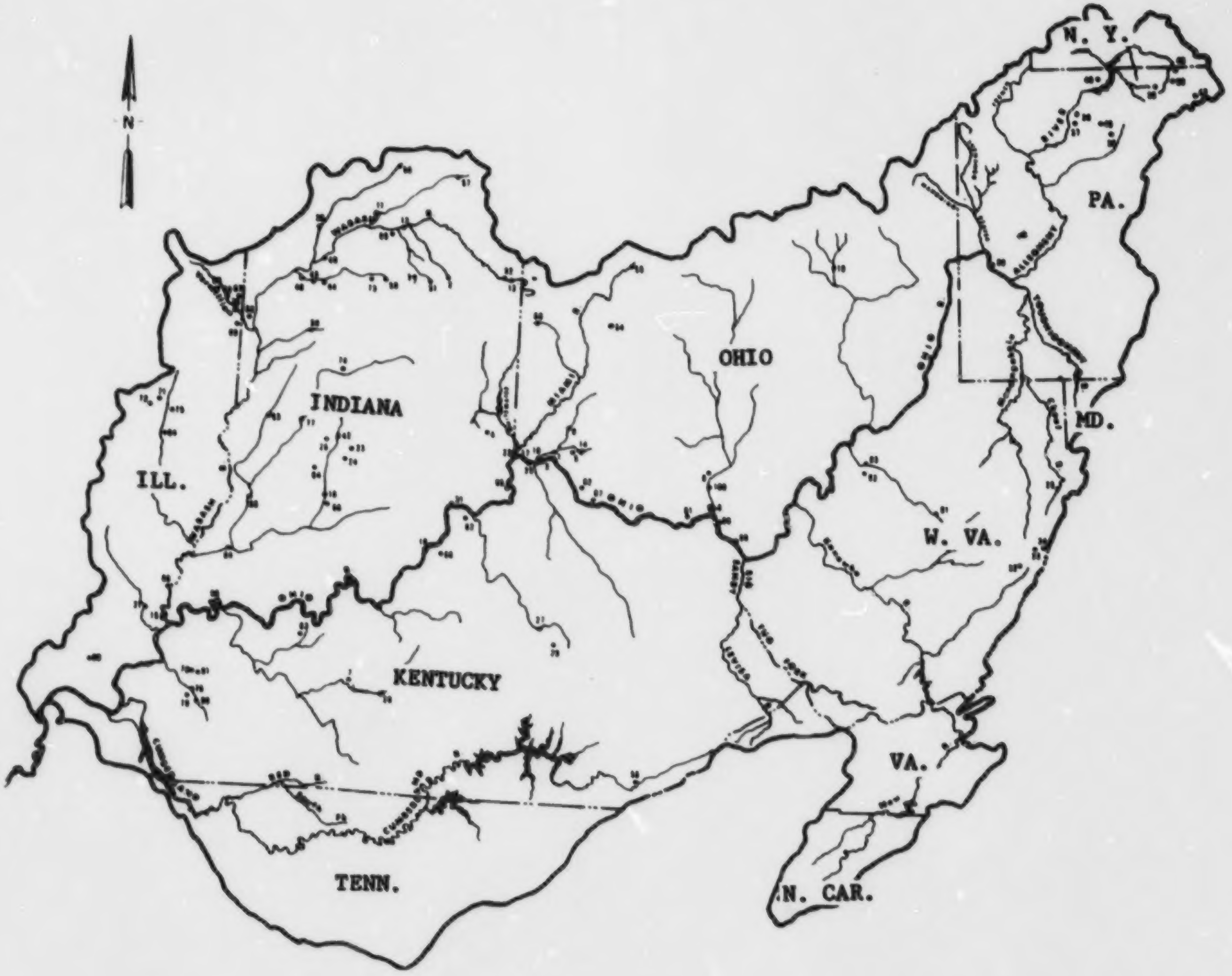

N
N. Y.
PA.
MD.
OHIO
W. VA.
VA.
N. CAR.
INDIANA
ILL.
KENTUCKY
TENN.

FIGURE 1. LOCATION OF *STENONEMA* COLLECTING SITES IN THE OHIO RIVER BASIN
(Refer to Appendix B for explanation of station numbers)

association. Species reared during the study were deposited in the museum of the Illinois Natural History Survey, Urbana, Illinois.

Nymphs, and most of the subimagos, were preserved in 70% ethanol. However, because imagos preserved in ethanol rapidly lose their color, some of each species were dry-mounted in order to preserve color patterns. The best results in pinning were obtained by gluing the specimens to cardboard points and using a numbering system to assure correct association.

To facilitate identification, male genitalia were slide-mounted in Turtox CMC-S mounting medium which cleared and stained the tissues for photographing. Other structures such as gills and mouthparts, were mounted in Turtox CMC-9AF to obtain maximum contrast. Opaque structures were cleared by digesting in a warm solution of potassium hydroxide for five or ten minutes before mounting in Diaphane.[1] Most structures were mounted dorsal side up. However, mandibles were mounted ventral side up to better show the teeth on the outer canines.

Before structures to be slide-mounted were removed from dried specimens, the insects were softened by placing them in a quart jar containing a damp sponge for 24 hours. A few drops of carbolic acid were added to the jar to prevent the growth of mold.

Photomicrographs of slide-mounted structures were made with a Zeiss Photomicroscope on Kodak Panatomic-X black and white film. Whole specimens were photographed with a Zeiss Tessovar photomacrographic unit. A camera lucida was used to make line drawings.

ECOLOGY AND LIFE CYCLE

Because of their flattened form, *Stenonema* nymphs are well adapted for clinging to rocks in swift water. However, they develop in a variety of habitats, ranging from lakes and large, slowly-flowing rivers to swift mountain streams. Nymphs of the *FEMORATUM (TRIPUNCTATUM* of other authors) group commonly inhabit the pools of small clay-bottom streams and *S. tripunctatum tripunctatum* (Banks) is also common in lakes. Nymphs of the *INTERPUNCTATUM* group are commonly found in pools between rapids in smaller streams, in sluggish, rock-bottom rivers, or along the rocky shores of lakes. Nymphs of the *PULCHELLUM* group inhabit moderately swift streams, usually between pools where there is constant current.

The greater part of the life history of *Stenonema* is spent in the nymphal stage, passing through a series of at least 25 instars that are present in the streams in various stages of development over the entire year (Ide, 1935). Adults emerge from the stream as subimagos and a few hours later shed the subimaginal skins and become imagos, which survive only a few days. Some species, e.g. *S. exiguum* Traver, emerge year-round, at least in the southern states (Berner, 1950). Others emerge during a very short period, e.g. *S. integrum* (McDunnough) which emerges from the Ohio River the last week in August and first week in October. In the later case, the nymphs are absent from the stream about one month of the year, depending on the incubation period of the eggs. The day after shedding the subimaginal skin, the female usually deposits several thousand eggs which hatch in 15-30 days (Needham, Traver and Hsu, 1935).

POLLUTION TOLERANCE

Species of *Stenonema* reported to be intolerant to organic pollution include *Stenonema femoratum* (Say), *S. interpunctatum canadense* (Walker), *S. smithae* Traver, *S. exiguum, S. fuscum* (Clemens), *S. interpunctatum frontale* (Banks), *S. interpunctatum interpunctatum* (Say), *S. tripunctatum tripunctatum* (Banks), and *S. rubromaculatum* (Clemens) (Gaufin, 1958; Gaufin and Tarzwell, 1952; Beck, 1954 and 1969; Neel, 1968; and Leonard, 1965). *Stenonema integrum, S. pulchellum* (Walsh), *S. ares* Burks, and *S. interpunctatum heterotarsale* (McDunnough) were found to be facultative in a midwestern stream (Gaufin, 1958).

A provisional classification of the tolerance of species of *Stenonema* to decomposable organic wastes is presented in Table 1. This classification is based on Chutter's (1972) Empirical Biotic Index in which organisms are rated on a linear scale of water quality in terms of tolerance to organic pollution. Each species is allocated a quality value between 0 and 11 depending on the type of water in which it usually occurs. The rating scheme is as follows:

Rating	Category	Definition of tolerance category
0-2	Intolerant	Found only in clean water.
3-5	Facultative 1	Generally found in clean water but able to withstand some organic enrichment if the Dissolved Oxygen concentration remains above 5.0 mg/1. and the pH and water temperature are not adversely altered.
6-8	Facultative 2	Tolerant of moderate to heavy organic pollution accompanied by brief periods of Dissolved Oxygen below 5.0 mg/1., pH changes not exceeding 2 units, and/or temperatures exceeding 25°C.

---

[1] Not presently available; Euparol is a good substitute.

9-11	Tolerant	Tolerant of gross organic pollution, generally accompanied by Dissolved Oxygen between 5.0 mg/1. and 0.0 mg/1., pH changes greater than 2 units, and/or temperatures above 25°C. for extended periods. No *Stenonema* fall in this category.

Because there are infraspecific differences in pollution tolerance, the table lists the quality values of each subspecies.

TABLE 1. POLLUTION TOLERANCE OF *STENONEMA* TO DECOMPOSABLE ORGANIC WASTES (Provisional)

Species	Intolerant	Falcultative 1	Falcultative 2	Insufficient Data
S. annexum				X
S. ares		5		
S. bipunctatum	1			
S. candidum	0			
S. carlsoni	1			
S. carolina	0			
S. exiguum		3		
S. femoratum			8	
S. floridense	0			
S. fuscum s.s.	1			
S. fuscum rivulicolum	2			
S. gildersleevei	0			
S. integrum s.s.			8	
S. integrum wabasha			7	
S. interpunctatum s.s.		4		
S. interpunctatum canadense	1			
S. interpunctatum frontale				X
S. interpunctatum heterotarsale			7	
S. ithaca		4		
S. lepton				X
S. luteum	1			
S. mediopunctatum	1			
S. minnetonka			6	
S. modestum				X
S. nepotellum		5		
S. pallidum	1			
S. placitum				X
S. pudicum	2			
S. pulchellum			8	
S. quinquespinum		5		
S. rubromaculatum	2			
S. rubrum			6	
S. smithae			8	
S. terminatum			6	
S. tripunctatum s.s.		5		
S. tripunctatum scitulum			7	
S. vicarium		4		

Tolerance of *Stenonema* nymphs to industrial wastes and pesticides is largely unknown. Leonard (1965) found *S. tripunctatum, S. ares, S. fuscum, S. interpunctatum* and *S. vicarium* (Walker) tolerant of copper and cyanide concentrations that had caused a complete fish kill. However, *Stenonema* nymphs were completely absent from the industrialized reach of the Upper Ohio River below Pittsburgh, although two species, *S. interpunctatum* and *S. integrum* were common above and below this reach (Mason et al., 1971). The genus is also absent from areas effected by acid mine drainage (Parsons, 1968) but several species have been reported from naturally acid streams (Bick et al., 1953). Heat pollution has also been mentioned as a limiting factor for the nymphs of *Stenonema* (Nebeker and Lemke, 1968).

The effect of siltation on the ecology of the nymphs was demonstrated by the distribution of *S. rubromaculatum* in the Cheat River at Rowlesburg, West Virginia, July 21, 1969 (Lewis, Unpublished). None of the nymphs were found by the author in silted Saltlick Creek which flows into the Cheat River or near the east bank of the river for a distance of 2,000 feet downstream from the confluence, although they were abundant elsewhere in the river.

HISTORY OF THE GENUS

The genus *Stenonema* was erected by Traver (1933a) to include American species of *Heptageniidae* that had previously been placed in *Heptagenia, Ecdyonurus,* and other genera by a number of workers, principally Needham (1901, 1905), McDunnough (1924, 1925a, 1925b, 1926, 1930, and 1933), and Ide (1930). For a brief history of the genus *Stenonema* see Spieth, 1947, p. 90.

Eight new species of *Stenonema* were described and the male imagos of all the known species were redescribed by Traver in *The Biology of Mayflies* (Needham, et al., 1935), probably the most important single contribution to the study of North American mayflies currently in print. In 1938, Spieth reported that coloration is influenced by geographic location, temperature, and bottom type so that the color patterns in both nymphs and adults are extremely variable. In 1947, Spieth synonymized eight previously described species of *Stenonema* and reduced seven others to subspecies on the bases of a statistical analysis of the ratio of the length of the second to the first fore tarsal segments and the ratio of the length of the fore wing to the first fore tarsal segment. Burks (1953) described three new species of *Stenonema,* synonymized four others, and redescribed most of the known nymphs and adults. Berner (1950) was the first to employ nymphal mouth parts to separate species of *Stenonema,* a practice commonly used in other genera, particularly the Baetidae (Traver and Edmunds, 1968, Mueller-Liebenau, 1969) and Leptophlebiidae (Peters and Edmunds, 1970).

GENERIC DESCRIPTION

Genus *Stenonema* Traver

Stenonema Traver, 1933a:173; Traver, 1933b:113; Traver, 1935:295; Spieth 1947:88; Burks, 1953: 154.

Type-species: *Stenonema tripunctatum* (Banks) originally in *Heptagenia*.

NYMPH: Body greatly flattened Heptagenine type (Fig. 2), length 6-20 mm.

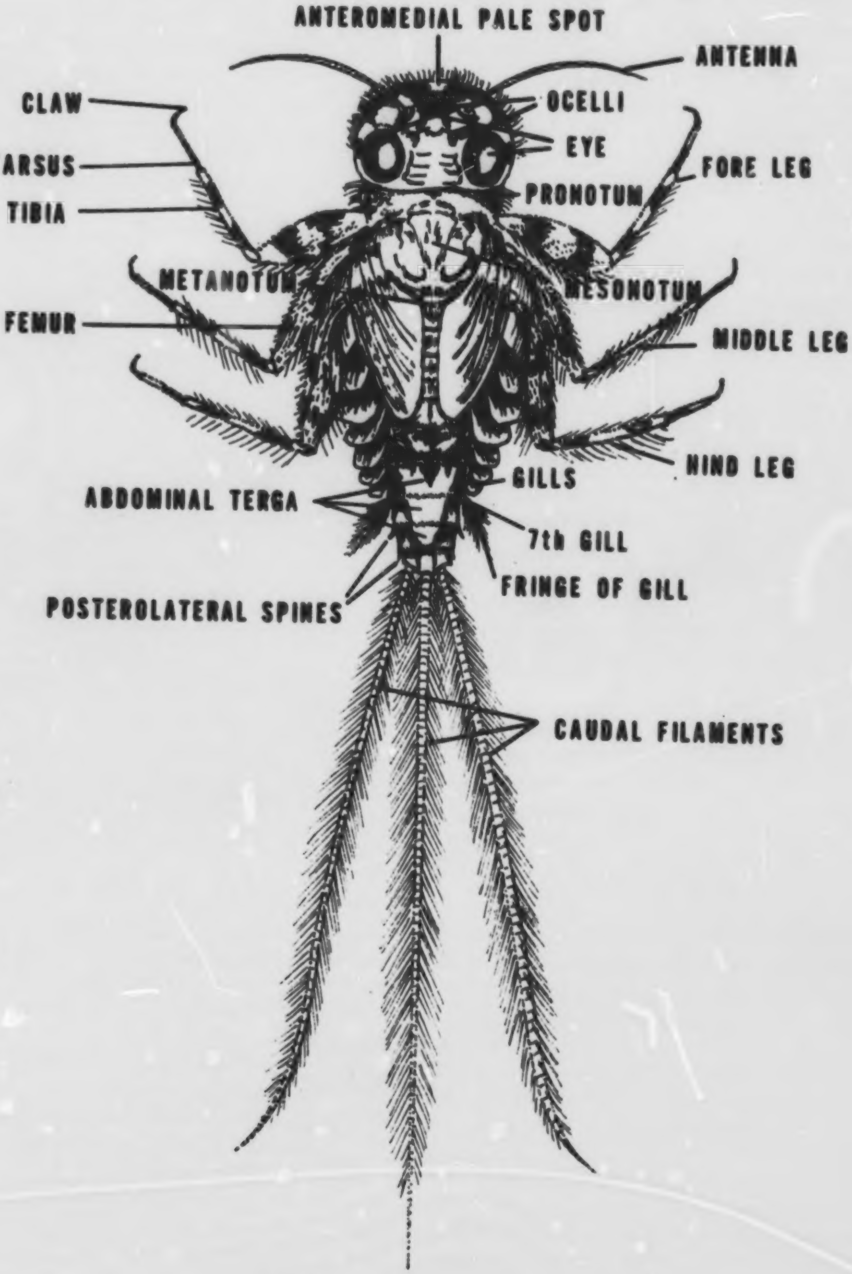

ANTEROMEDIAL PALE SPOT
ANTENNA
CLAW
OCELLI
EYE
TARSUS
FORE LEG
PRONOTUM
TIBIA
METANOTUM
MESONOTUM
FEMUR
MIDDLE LEG
HIND LEG
GILLS
ABDOMINAL TERGA
7th GILL
FRINGE OF GILL
POSTEROLATERAL SPINES
CAUDAL FILAMENTS

FIGURE 2. SCHEMATIC DRAWING OF A *STENONEMA* NYMPH

Head: Hypognathous, large, flattened, wider than long; eyes dorsal, occupying posterolateral quarter of head; labrum broad with smooth anterior margin; *maxilla* (Fig. 3) with a two segmented palpus that is unevenly setose; inner lacinal edge with two dense rows of simple setae (inner lacinal setae), three slender distal lacinal denticles (=terminal tridents), several long slender proximal lacinal setae, and a row of plumose lateral setae near lacinal edge; distal margin of galea (=crown of maxilla) with from 2-13 heavy setae that vary from plumose spines (Fig. 62) to sturdy pectinate combs (Fig. 57), simple setae often also present with spines on crown (Fig. 70); *left mandible* (Fig. 4) with an outer canine bearing a row of 4-12 teeth on inner margin, a large apical tooth, and an additional tooth on the outer margin just proximal to the apex (Fig. 85); an inner canine with three large teeth at apex; and a strong pectinate seta called a lacinia mobilis; *right mandible* similar to the left except that it lacks a lacinia mobilis and the inner tooth on the inner canine is produced as a sharp spur (Fig. 80).

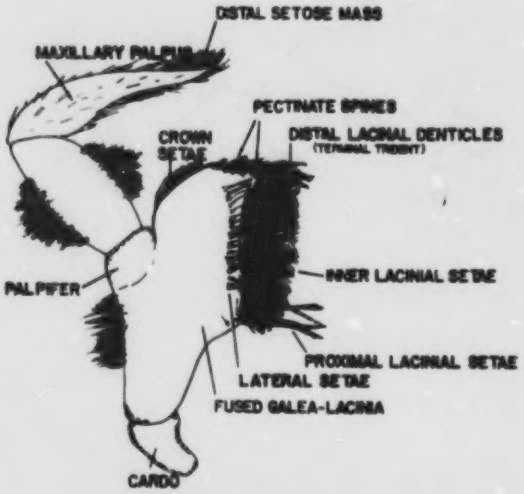


FIGURE 3. SCHEMATIC DRAWING OF RIGHT MAXILLA OF *STENONEMA* NYMPH (Ventral view)

Thorax: Heavily chitinized dorsally, prothorax with thin sharp lateral edges, meso- and metathorax fused dorsally, each bearing a pair of wing pads; *legs* flattened and fringed with hairs along posterior margins; femora armed with short spines and bristles, dorsal surface with two transverse dark bands, ventral surface usually smooth and unbanded; tibiae armed with two rows of short spines along each margin, posterior margin also fringed with a row of long bristles; each tarsus of one segment, armed with a row of spines on posterior margin; claws at distal end of tarsi, each claw often bearing a row of pectinations near apex (Fig. 110).

Abdomen: Depressed and tapering rearward, consisting of 10 segments; *terga* convexly arched in middle, meeting flat sterna to form a sharp edge, posterior margin of each tergum with a row of short spines; *posterolateral angles* of some segments (especially 7-9) extended as sharp spines; *gills* dorsal, not utilized as adhesive organs, first six gills consist of lamellate dorsal and fibrillar ventral parts (Fig. 10), seventh gill single, slender, and lanceolate without the fibrillar part (Fig. 9); *caudal filaments* three in number and of about equal length.

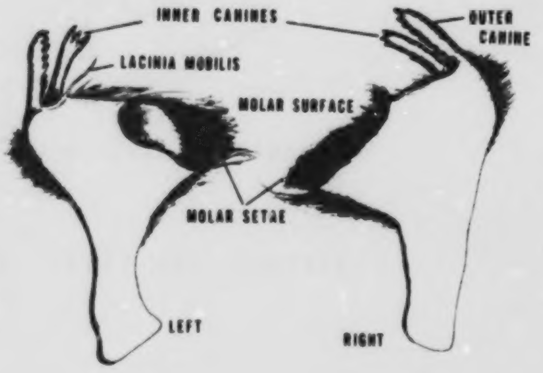


FIGURE 4. SCHEMATIC DRAWING OF MANDIBLES OF *STENONEMA* NYMPH (Dorsal view)

MALE IMAGO: Length: Body 5-15 mm; fore wings 6-17 mm; caudal filaments 7-20 mm.

Head: Eyes moderately large but separated on meson by a space about the diameter of a lateral ocellus; three ocelli arranged in a triangle occupy median facial area; antennae each with about 25 segments, shorter than head, basal segment (scape) short and thick, second segment (pedicel) proportionally longer, remaining segments very slender forming the flagellum; mouthparts vestigial, forming a whitish mass beneath the clypeus.

Thorax: Prothorax small and closely appressed to the head, bearing a pair of forelegs; meso- and metathorax strongly developed and fused together, each bearing a pair of wings and a pair of legs; *fore legs* as long or longer than the body (Fig. 5) (except *S.*

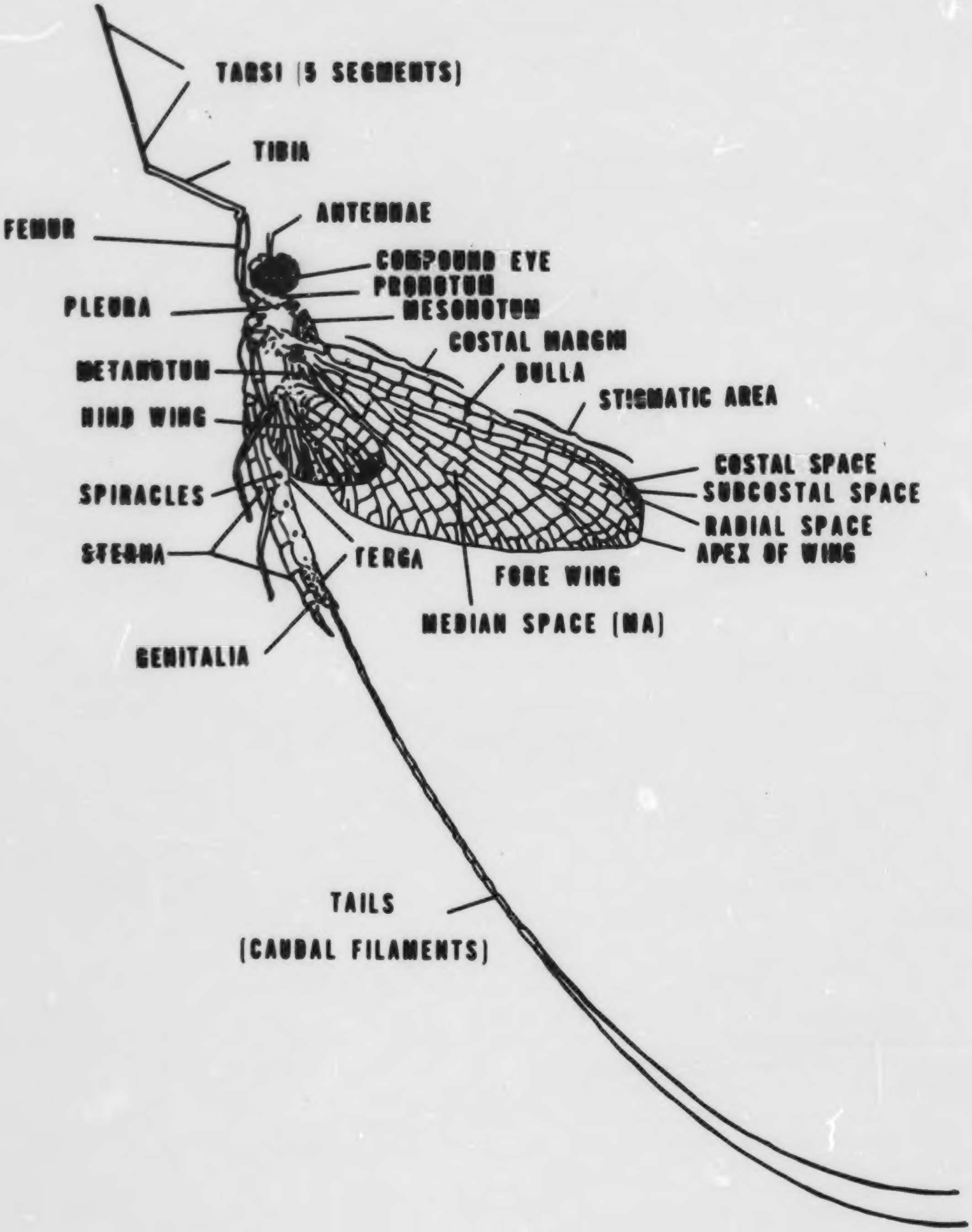
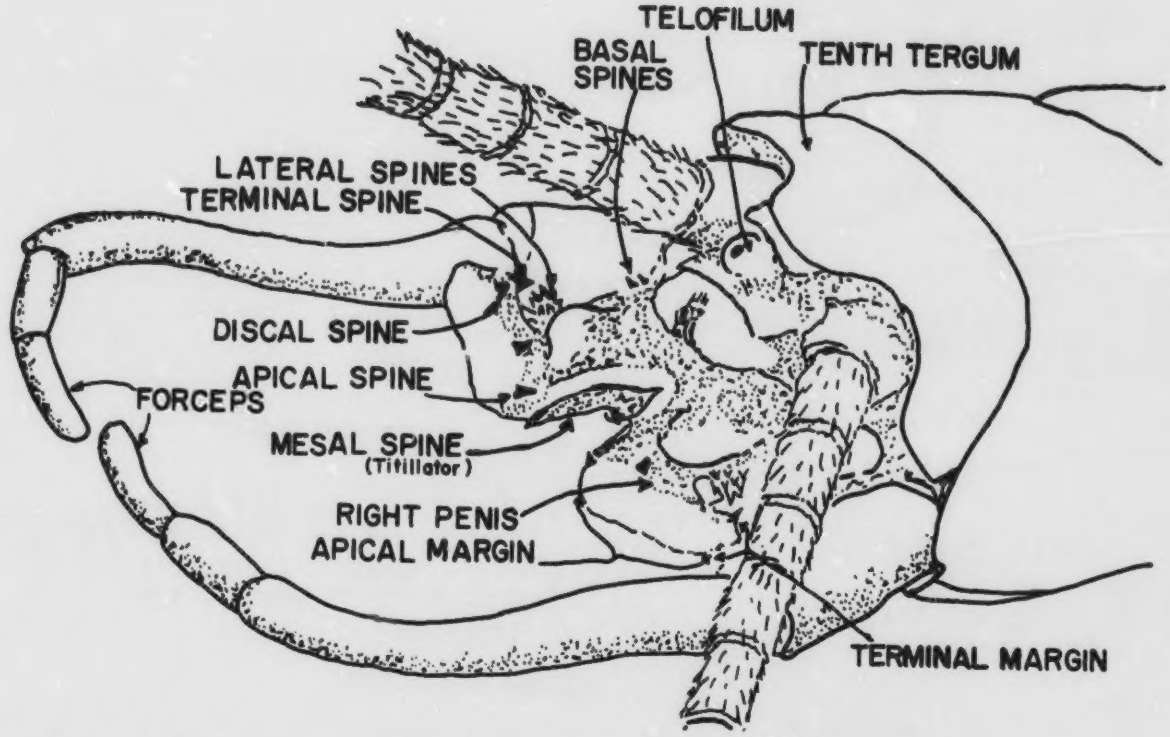

TARSI (5 SEGMENTS)
TIBIA
ANTENNAE
FEMUR
COMPOUND EYE
PRONOTUM
PLEURA
MESONOTUM
COSTAL MARGIN
METANOTUM
BULLA
STIGMATIC AREA
HIND WING
COSTAL SPACE
SPIRACLES
SUBCOSTAL SPACE
RADIAL SPACE
STERNA
TERGA
APEX OF WING
FORE WING
MEDIAN SPACE (MA)
GENITALIA
TAILS
(CAUDAL FILAMENTS)

FIGURE 5. DRAWING OF *STENONEMA FUSCUM* MALE IMAGO
(From Leonard and Leonard, 1962)


TELOFILUM
BASAL SPINES
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TERMINAL SPINE
DISCAL SPINE
APICAL SPINE
FORCEPS
MESAL SPINE (Titillator)
RIGHT PENIS
APICAL MARGIN
TERMINAL MARGIN

FIGURE 6. THREE DIMENSIONAL DRAWING OF MALE GENITALIA OF *STENONEMA* IMAGO

integrum where they are slightly shorter than the body), fore tarsus usually longer than fore tibia, first fore tarsal segment varies from 1/3 - 4/5 length of second segment (ratio of second segment to first segment 1.2-3.0), third tarsal segment about equal to second, fourth shorter than the third, and fifth segment shortest of all, other legs much shorter than forelegs and the tarsal segments subequal; *fore wing* typical for the Heptageniidae with basal cross veins well developed in costal area, cross veins in bulla area sometimes crowded (Fig. 154), and stigmatic cross veins sometimes aslant or forked but never anastomosed; *hind wing* with one to four marginal intercalaries between Cu_1 and Cu_2 (Fig. 149, 155). **Abdomen:** Consists of 10 distinct segments (11th and 10th fused according to Needum et al., 1935), terminating in the genitalia and two tails or caudal filaments (=cerci) (Fig. 5); each ring-like abdominal segment consists of a convexly arched tergum and a transverse sternum which meet laterally; segments 1-8 with a pair of spiracles often surrounded by dark pigment (spiracular dots) (Fig. 143); *genitalia* (Fig. 6) consists of a four segmented forceps and two L-shaped penis lobes usually deeply divided, each lobe with a strong mesal spine (=median titillator) on inner margin and usually armed with an apical and a terminal, subterminal, or discal spine (Fig. 7).

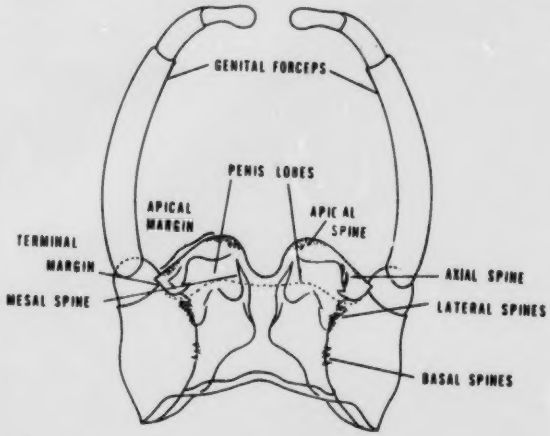
GENITAL FORCEPS
PENIS LOBES
APICAL MARGIN
APICAL SPINE
TERMINAL MARGIN
MESAL SPINE
AXIAL SPINE
LATERAL SPINES
BASAL SPINES

FIGURE 7. SCHEMATIC DRAWING OF MALE GENITALIA OF *STENONEMA* IMAGO (Dorsal view)

FEMALE IMAGO: The female resembles the male in general appearance and coloration except that the abdominal coloration is often obscured by the yellowish eggs visible through the integument.

Morphological differences of the female include smaller and more widely separated eyes, shorter forelegs, subequal tibia and femur, tarsi shorter than tibia, tarsal segments nearly subequal, cross veins and dark pigment in bulla region of fore wing and dark margin on hind wing more variable than in male, and posterior margin of ninth sternum rounded, without prominant process (Fig. 130).

SUBIMAGO: Practically identical to imagos except for a dull grey appearance, legs and tails shorter, and wing borders more pubescent than imagos; genitalia not fully developed.

DISCUSSION

Nymphs of *Heptagenia, Epeorus, Cinygma* and *Traverella* are sometimes confused with *Stenonema.* All of these except *Traverella* have plate-like seventh gills, and *Traverella* is distinguished by the head capsule not covering the mandibles and by the bilamillate gills (segments 1-5) the margins of which are finely dissected to form numerous long filaments. The arrangement of spines and setae on the maxillae also serves to differentiate *Traverella* and *Heptagenia* nymphs from *Stenonema.* In *Traverella* the crown of the maxilla is thickly crowded with long setae with no spines, there is only one small distal lacinal denticle, and there are no lateral setae. In many *Heptagenia* the lateral setae are scattered over the lacinal face instead of being arranged in a row and there are 9 or more (usually more than 13) heavy comb-like spines the width of the crown of the maxilla (Fig. 53). Mandibles of all *Heptagenia* nymphs have more than one lacinia mobilis (Fig. 79). The vestigial median caudal filament of *Epeorus* nymphs also serves to distinguish them from *Stenonema.*

Adult males of *Stenonema* can be separated from *Heptagenia* only by an examination of the genitalia. In *Stenonema* the penis lobes are more L-shaped than in *Heptagenia* except for some of the *INTERPUNCTATUM* group where the penis lobes are armed with lateral spines not found in *Heptagenia.* The ratio of the second fore tarsal segment to the first fore tarsal segment in *Stenonema* falls between 1.0 and 3.0 whereas in *Epeorus, Rhithrogena,* and most of the *Heptagenia* the ratio is either less than 1.0 or greater than 3.0. See Burks (1953, p. 151) for diagnostic keys to the genera of Heptageniidae and illustrations of the genitalia.

Females of *Stenonema* are difficult to distinguish from *Heptagenia* unless association with males can be established. However, Koss (1968) has reported diagnostic differences in egg morphology.

DIVISIONS OF THE GENUS

Traver (1933a, 1933b) divided the genus into three groups based on the structure of the nymphal gills: *INTERPUNCTATUM, VICARIUM,* and *TRIPUNCTATUM.* She later (1935) changed the name of *VICARIUM* to *PULCHELLUM.* Burks (1953) recognized seven groups in this genus based mostly on adult characters. The divisions employed in this paper are easily recognized in the eggs, nymphs, and imagos, and are probably sufficiently different to be considered as distinct subgenera. Characteristics of the species groups are summarized in tables following the keys.

The *INTERPUNCTATUM* Group[1]

Nymph: Nymphs of the *INTERPUNCTATUM* group are characterized by the pointed gills on abdominal segments 1-6 (Fig. 8) and the lack of a fringe of setae on the margins of the seventh gill (Fig. 9). The crown of each maxilla has 8-13 heavy pectinate spines but no setae (Fig. 55). There are 15-45 lateral setae along the lacinal edge of each maxilla. The posterolateral angles of abdominal segments 1-6 are not produced as spines.

Male imago: Males are characterized by the spines on the lower lateral margins (lateral spines) of the penis lobes (Fig. 169) (except in *S. carolina),* and by the black-margined cross veins in the basal portion of the costal, subcostal, and radial spaces of the fore wings. These black margins are wider in the middle of the cross veins than at the ends (Fig. 148). Two or three cross veins in the radial interspace below the bulla are usually connected by a black pigmented line. If these veins are not connected, there is a black dot on each (Fig. 152).

Female imago: Females are similar to the males except for the usual dimorphic differences and can be identified only by association with the males or by a study of the egg morphology. The eggs differ from the other two groups and *Heptagenia* in possessing polar caps (Koss, 1968).

DISCUSSION

The *INTERPUNCTATUM* group consists of seven species: *S. gildersleevei* Traver, *S. pallidum* Traver, *S. carolina* (Banks), *S. candidum* Traver, *S. minnetonka* Daggy, *S. interpunctatum,* and *S. floridense* Lewis, a new species from the Blackwater River, Florida. Although numerous other species have been described, Spieth (1947) synonymized most of them with *S. interpunctatum* or relegated them to subspecies (see Table 2).

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[1] The *INTERPUNCTATUM* group was described as a new genus, *Stenacron* Jensen (Proc. Ent. Soc. Wash. 76:225-228, 1974), as this manual went to press.

The *FEMORATUM* Group

Nymph: Nymphs of the *FEMORATUM* group are characterized by rounded gills on abdominal segments 1-6 (Fig. 10). The seventh gill is fringed and contains a single trachea which may branch once near the base (Fig. 11). The crown of each maxilla bears two to four pectinate spines followed by 2-35 setae (Fig. 58). Along the lacinal edge of each maxilla are 20-40 lateral setae (Fig. 61). Large posterolateral spines are present on segments 3-9 (Fig. 39).

Male imago: Imagos are easily recognized by the three dark transverse marks at the posterior margins of terga 2-8 (Fig. 127). The cross veins in the bulla region are crowded but never connected by a black line (Fig. 154). Lateral spines are lacking on the penis lobes, and the posterior (apical) margins are nearly straight (Fig. 171).

Female imago: Females are similar to males except for the usual secondary sexual characteristics. Also, females of the two species tend to have less crowding of the cross veins in the bulla region and less pigment in the apical margin of the hind wing than do the males. The eggs lack both polar caps and sperm guide hoods (Koss, 1968).

DISCUSSION

In this group, Spieth (1947) recognized a single species consisting of three subspecies. However, based on his study of adults, Burks (1953) recognized *S. femoratum* and *S. tripunctatum* as separate species. Both species are common in small creeks in southern Ohio and Kentucky, and show little evidence of intergradation. There are distinct morphological differences between the two species in the adults and nymphs, and Koss (1968) has shown that there are obvious differences in the eggs. A third phenon (*S. scitulum* Traver) is presently considered a subspecies of *S. tripunctatum*, for reasons mentioned under the discussion of that species.

The *PULCHELLUM* Group

Nymph: Nymphs of the *PULCHELLUM* group are characterized by the truncated gills on segments 1-6 (Fig. 12) and the heavily fringed seventh gill which lacks tracheae (Fig. 13). Each maxilla bears 2-9 spines and 0-50 setae on the crown and 15-45 lateral setae along the lacinal edge. Development of spines at the posterolateral angles of the abdominal segments varies from species to species.

Male imago: Males are characterized by the absence of a black line or dark pigmented spot connecting the cross veins in the bulla region of the fore wing, the absence of lateral spines on the penis lobes, and the absence of three dark transverse marks at the posterior margin of abdominal terga 2-8 (there may be one or two dark transverse marks or a dark band).

Female imago: Females are similar to the males except for the usual sexual characteristics. It is presently impossible to identify many of the females to species, but the females of this group can be separated from the other two groups by characters used in the key and verification tables, and by the eggs, which differ from those of the other two groups and from *Heptagenia* in possessing sperm guide hoods (Koss, 1968).

DISCUSSION

The taxonomic status of several species in the *PULCHELLUM* group needs further clarification. The synonymies listed in Table 2 give some idea as to the scope of the problem.

SYSTEMATICS

The taxonomy of the genus has been confused because past keys and descriptions have not employed reliable characters. Descriptions of new species have been based on phenotypic differences in the adults, while the nymphs have generally been ignored. Many of the descriptions of adults and nymphs have been based almost entirely on coloration and size differences, both of which may be extremely variable within a given species (Spieth, 1938, 1947). Nymphs of at least ten species are either unknown or have not been positively associated with the imagos.

As with most mayflies, coloration varies with the environment, season, and geographical distribution of the species (Spieth, 1938), and has been overemphasized in the taxonomy of both imagos and nymphs of the genus *Stenonema*. Dorsal color pattern is even less reliable for nymphs than for adults, but ventral maculation seems to be consistent. Since color patterns are often obscured by generalized melanistic shading (Spieth, 1947), coloration is used as a key character in this manual only when found to be consistent and when no other differences could be found to separate the species.

More reliable imaginal characters include: the shape and arrangement of spines on the penis lobes, the arrangement of cross veins in the bulla region of the fore wings, the ratio of the first fore tarsal segment to the length of the fore wing, and the ratio of the length of the first fore tarsal segment to the length of the second (fore tarsal ratio). It should be noted that the fore tarsal ratio will be proportionately greater on specimens that are killed while in the process of shedding the subimaginal skin, because the legs do not expand to normal size until after the subimaginal skin has been completely shed.

Reliable diagnostic characters for nymphs include: the number and arrangement of spines and setae on the maxillae, the number of teeth on the inner margin of the outer canine of the mandible, the shape of the abdominal gills, the presence or absence of pectinations near the apex of the tarsal claws, and presence or absence of spines on the posterolateral angles of abdominal segments. Some of these characters, however, are useful only in separating later instar nymphs, and the keys must be used with caution with less mature specimens.

An attempt was made to keep nomenclatural changes in this manual to a minimum even though the genus needs a complete revision. The author's study of museum collections and reared specimens mostly from the Ohio River Basin has resulted in the discovery of four new synonyms, three new species, and several other taxonomic changes which are summarized here and discussed in detail following the description of the species involved.

After a careful study of the type series of *S. areion* Burks, the species was considered synonymous with *S. interpunctatum canadense* in harmony with Spieth's (1947) diagnosis of the *INTERPUNCTATUM* group. Based on reared specimens and study of the type series of *S. scitulum* Traver, the author considered this taxon a subspecies of *S. tripunctatum* rather than *S. femoratum*; and *S. femoratum* is considered a valid species distinct from *S. tripunctatum*. *Stenonema varium* Traver is synonymized with *S. rubrum* (McDunnough), since no significant differences were observed between the types. Rearing confirmed Burks' suggestion that *S. metriotes* Burks is a synonym of *S. integrum*. The author considered the resurrection of *S. placitum* (Banks) and *S. pallidum* necessary because the arrangement of spines on their genitalia is distinctly different from that on the genitalia of *S. terminatum* (Walsh) and *S. interpunctatum* respectively.

A comparison of the fore tarsal ratios of *S. exiguum* and *S. alabamae* Traver convinced the author that *S. alabamae* is a junior synonym of *S. exiguum*. Based on a comparison of the male genitalia of its types, *S. rivulicolum* (McDunnough) is considered a junior synonym of *S. fuscum* rather than *S. vicarium*. The author believes that *S. modestum* (Banks) belongs in the genus *Stenonema* as Burks (1953) indicated. Three new species *Stenonema quinquespinum* Lewis, *S. carlsoni* Lewis and *S. floridense* Lewis were described as a result of this study (Lewis, 1974). Species of *Stenonema* recognized by the author and synonymous species of other authors are presented in Table 2 following the keys. The systematic list of species given by Edmunds (1962) was used as the basis for this manual.

Structures used in the following keys are shown in Figures 2 through 7. Summary tables of diagnostic characters which follow the keys and the photographs should be used in conjunction with the keys. The nymphs of *S. modestum, placitum,* and *lepton* are not known. Although all the known species of *Stenonema* are included in the following keys, they should be used with caution outside the Ohio River Basin, because as yet undescribed species are commonly encountered in other parts of the country and the extent of geographical variation within the various species is unknown.

Key to the mature nymphs

1. Gills on abdominal segments 1-6 pointed at apices (Fig. 8); 8-13 pectinate spines on crown of maxilla (Fig. 57) .... *INTERPUNCTATUM* GROUP 3
Gills on abdominal segments 1-6 truncated or rounded at apices, 2-9 pectinate spines on crown of maxilla 2

2. Gills on abdominal segments 1-6 rounded at apices (Fig. 10); 2-5 pectinate spines on crown of maxilla (Fig. 58); seventh gill with a single or branched trachea (Fig. 11) .... *FEMORATUM* GROUP 9
Gills on abdominal segments 1-6 distinctly truncated at apices (Fig. 12); 2-9 pectinate spines on crown of maxilla (Fig. 62); seventh gill without tracheae (Fig. 13) .... *PULCHELLUM* GROUP 10

3. Each maxilla with 30 or more lateral setae (Fig. 60) 4
Each maxilla with less than 30 lateral setae 5

4. Crown of maxilla with 8-10 pectinate spines (Fig. 60); sterna 7-9 with dark bands or spots at lateral margins .... *S. minnetonka*
Crown of maxilla with 11-13 heavy pectinate spines (Fig. 59); sterna 7-9 without dark bands or spots .... *S. gildersleevei*

5. Inner margin of outer canine of left mandible with 8 teeth (Fig. 82) .... *S. candidum*
Inner margin of outer canine with 5-7 teeth (Fig. 85) 6

6. Dorsum nearly uniform brown, without pale longitudinal streaks (Fig. 17), venter entirely pale .... *S. carolina*
Dorsum with longitudinal pale streaks the length of abdomen (Fig. 14), usually with some distinct dark markings on posterior sterna (Fig. 35) 7

7. Crown of maxilla with 11-13 pectinate spines (Fig. 57) .... *S. pallidum*
Crown of maxilla with 8-10 pectinate spines (Fig. 56) 8

8. Mid-dorsal pale streaks continuous or nearly so, widely distributed .... *S. interpunctatum*
Mid-dorsal pale streaks discontinuous, distribution limited to naturally acid streams of the Gulf States .... *S. floridense*

9. Two pectinate spines on crown of maxilla (Fig. 58); anterior margin of head emarginate (Fig. 18), posterior half of sternum 9 usually brown (Fig. 38) .... *S. femoratum*
Three to five pectinate spines on crown of maxilla (Fig. 61); anterior margin of head not emarginate, four black spots on sternum 9 (Fig. 39) .... *S. tripunctatum*

10. Crown of maxilla with pectinate spines but no setae (Fig. 62) 11
Crown of maxilla with setae in addition to pectinate spines (Fig. 75) 19

11. Posterolateral angles of abdominal segments 3, 4, or 5-9 extended as spines (Fig. 42) 12
Posterolateral angles of abdominal segments 7 to 9 only extended as spines (Fig. 49) 14

12. Crown of maxilla with 7 or 8 pectinate spines (Fig. 64) .... *S. carlsoni*
Crown of maxilla with 3 to 6 pectinate spines 13

13. Inner margin of outer canine with 7 or 8 teeth (Fig. 108); maxilla with 25-30 lateral setae (Fig. 68) .... *S. nepotellum*
Inner margin of outer canine with 5 or 6 teeth (Fig. 90); maxilla with 20-25 lateral setae .... *S. bipunctatum*

14. Sterna 2-7 without dark markings (Fig. 50), claws often pectinate 15
Sterna 2-7 with distinct dark markings (Fig. 48), claws not pectinate 18

15. Anastomosed large white spots forming a pale band across base of wing pads (Fig. 23); if band not evident in pale specimens then claws not pectinate 16
Base of wing pads without anastomosed spots or pale band (a few small spots may be present), claws pectinate in pale specimens 17

16. Sterum 9 with dark lateral margin (Fig. 50), claws not pectinate .... *S. quinquespinum*
Sterum 9 dark only at posterolateral angles, claws pectinate (Fig. 117) .... *S. exiguum*

17. Tergum 7 mostly white, claws pectinate (Fig. 114) .... *S. pulchellum*
Tergum 7 mostly dark, claws not pectinate (Fig. 115) .... *S. ares*

18. Transverse brown band present at middle of sterna 4-8 (Fig. 41) .... *S. ithaca*
Brown stripes and spots present on sterna 4-8 but not forming a transverse brown band (Fig. 48) .... *S. terminatum*

19. Posterolateral angles of abdominal segments 3-9 extended as spines (Fig. 47) 20
Posterolateral angles of abdominal segments 7-9 only extended spines (Fig. 51) 26

20. Posterior fourth to half of sterna 7 and 8 dark brown or black (Fig. 45) 21
Posterior fourth of sterna 7 and 8 pale (Fig. 44) 23

21. Black posterior band on sternum 8 extending forward in sublateral areas to middle of sternum (Fig. 45), claws pectinate (Fig. 111) .... (Canada) .... *S. luteum*
Black band at posterior margin of sternum 8 the same width across sternum (Fig. 46), claws not pectinate (Fig. 109) 22

22. Entire posterior half of sternum 9 dark brown (Fig. 47); maxilla with 15-25 lateral setae (Fig. 72) .... *S. vicarium*
Only posterolateral angles of sternum 9 dark brown (Fig. 46); maxilla with 25-35 lateral setae (Fig. 75) .... *S. fuscum*

23. Less than 10 crown setae on maxilla (Fig. 78) (If venter lacks dark markings go back to couplet 12.) .... *S. mediopunctatum*
More than 10 crown setae on maxilla (Fig. 77) 24

24. Claws without pectinations (Fig. 118); sterna marked as in Figure 43 .... *S. pudicum*
Claws with pectinations (Fig. 111); sterna marked as in Figure 40 or 48 25

25. Maxilla with 2-4 pectinate crown spines and less than 25 lateral setae (Fig. 77); 6 or 7 teeth on inner margin of outer canine (Fig. 98) (Wissonsin) .... *S. luteum*
Maxilla with 4-7 pectinate crown spines and 20-35 lateral setae (Fig. 76); 8 or 9 teeth on inner margin of outer canine (Fig. 103) .... *S. rubromaculatum*

26. Maxilla with 2 or 3 pectinate spines (Fig. 70); V-shaped pale mark covering terga 7, 8 and 9 (Fig. 25) .... *S. integrum*

Maxilla with 4-6 pectinate spines; no V-shaped pale mark on terga 7-9 27

27. Sterna 8 and 9 usually without dark markings .... *S. annexum*

Sterna 8 and 9 with dark markings (Figs. 51 & 52) 28

28. Maxilla with 15-25 setae on crown (Fig. 74); V-shaped dark brown mark on sternum 9 with vertex at anterior margin (Fig. 51) .... *S. rubrum*

Maxilla with 30-40 setae on crown (Fig. 73); lateral margins of sternum 9 dark, the bands sometimes meeting at anterior margin (Fig. 52) .... *S. smithae*

Characters for separating nymphs to species groups:

Character	Group		
	INTERPUNCTATUM	*FEMORATUM*	*PULCHELLUM*
Gills 1-6	pointed	rounded	truncate
7th gill	not fringed	fringed	fringed
Claws	not pectinate	pectinate	both types
Tracheae in 7th gill	present	present	absent
Pectinate spines on maxillae	8-13	2-4	3-9
Crown setae	none	1-35	0-50

Characters of *INTERPUNCTATUM* group nymphs:

Character	*S. carolina*	*S. candidum*	*S. floridense*	*S. gildersleevei*	*S. interpunctatum*	*S. minnetonka*	*S. pallidum*
Maxilla:							
Spines on crown	10	7-9	8-9	11-13	8-10	8-10	11-13
Lateral setae	20-30	15-25	20-25	30-45	20-30	30-40	20-25
Mandible (left):							
Teeth on inner canine	2	0	4	3-7	2-5	4	2
Teeth on outer canine	7-8	8	7	7-9	5-7	6-7	5-8
Terga:							
Mid-dorsal pale streaks	absent	present	present	present	present	present	present
Dark posterior margins	absent	absent	absent	absent	present	absent	absent
Dark markings on sterna 9	absent	present	present	present	absent	present	present

Characters of *FEMORATUM* group nymphs:

Character	*S. femoratum*	*S. t. tripunctatum*	*S. t. scitulum*
Maxilla:			
Number of spines on crown	2	3-5	3
Crown setae	2-15	10-30	10-15
Lateral setae	30-40	20-35	25-35
Dark spots on sterna	5-9 (or more)	2-9	2-9
Anterior margin of head emarginate	yes	no	no

Characters of *PULCHELLUM* group numphs:[1]

Species	Crown of maxilla		Teeth on inner margin of outer canine	Lateral setae on maxilla	Postero-lateral spines on abdominal segments	Wide dark posterior margin on sterna	Claws pectinate[2]
	pectinate spines	setae					
S. annexum	4 or 5	25-30	6 or 7	20-25	7-9	no	yes
S. ares	3 or 4	0	6 or 7	15-25	7-9	no	no
S. bipunctatum	3 or 4	0	5 or 6	20-25	4?-9	no	yes?
S. carlsoni	7 or 8	0	8-10	25-45	3-9	no	no?
S. exiguum	4-9	0	6-8	18-25	7-9	no	yes
S. fuscum	2-4	10-40	7 or 8	25-35	3-9	yes	no
S. integrum	2 or 3	30-50	5-8	15-25	7-9	no	no
S. ithaca	4-6	0	6 or 7	15-26	7-9	no	no
S. luteum	2-4	30-40	6 or 7	18-25	3-9	yes	yes
S. mediopunctatum	4-6	1-5	7 or 8	30-40	3-9	no	no
S. nepotellum	4-6	0	7 or 8	25-30	5-9	no	yes
S. pudicum	5-8	20-40	10 or 11	30-40	3-9	no	no
S. pulchellum	4-6	0	6 or 7	15-30	7-9	no	yes
S. quinquespinum	4 or 5	0	7 or 8	20-30	7-9	no	no?
S. rubromaculatum	4-7	30-50	8 or 9	20-35	3-9	no	yes
S. rubrum	4-6	15-25	7-9	15-25	7-9	no	yes
S. smithae	4-6	30-40	7 or 8	20-30	7-9	no	yes
S. terminatum	4-6	0	5-7	13-26	7-9	no	no
S. vicarium	2-4	10-25	7 or 8	15-25	3-9	yes	no

[1] Nymphs of *S. lepton*, *S. modestum*, and *S. placitum* not known.

[2] Two minute pectinations near tip of the claw.

Key to male imagos

1. Penis lobes of genitalia (except *S. carolina)* with lateral spines (Fig. 169); basal cross veins of fore wings in costal, subcostal, and radial spaces thickened and with dark margins in middle; 2 or 3 cross veins below bulla connected by a black dash or with a black spot in the middle of one or more of the veins (Fig. 150) .... *INTERPUNCTATUM* GROUP 3

   Penis lobes of genitalia without lateral spines (Fig. 183); basal cross veins in costal, subcostal, and radial spaces without dark margins in middle and without black dash or dots below bulla (Fig. 162) 2

2. Posterior margins of abdominal terga 2-8 with 3 black marks, a median dot, and a pair of submedian, transverse dashes (Fig. 127) .... *FEMORATUM* GROUP 10

   Posterior margins of abdominal terga marked otherwise .... *PULCHELLUM* GROUP 11

3. Outer lateral margins of penis lobes with a cluster of large spines (Fig. 169) 4

   Outer lateral margins of penis lobes without a cluster of large spines (Fig. 167), extremely minute spines may be present (Fig. 170) 9

4. Penis lobes with terminal or subterminal spines (Fig. 168) 5

   Penis lobes with discal spines (Fig. 165) (See Fig. 6) 6

5. Venter of abdomen with a median, longitudinal, dark line extending from anterior to posterior ends, this line slightly widened and with a narrow interruption at posterior margin of each sternum .... *S. gildersleevei*

   Venter not as above, usually entirely pale or faint dark marks at posterior margin of some sterna ...... (ssp. *canadense*) ...... *S. interpunctatum*

6. Two or more large axial spines on penis lobes (Fig. 166) .... *S. floridense*

   No axial spine on penis lobes (Fig. 165) 7

7. Apical spine of each penis lobe, if present, smaller than discal spine (Fig. 165); black streak often present on pleuron ventral to fore wing base (Fig. 124) 8
Apical spine of each penis lobe larger than discal spine; dark spiracular dots present on abdominal terga; black line on face ventral to antennal sockets (as in Fig. 125); no black streak on pleuron ventral to fore wing base .... *S. minnetonka*

8. Either with black dash connecting cross veins below bulla in fore wing (Fig. 150), with spiracular dots present (Fig. 124), or with dark pleural streaks present ... (ssp. *interpunctatum*, *frontale*, and *heterotarsale*) ... *S. interpunctatum*
Black dash not connecting cross veins below bulla in fore wing, spiracular dots and dark pleural streaks absent (Fig. 120) ... *S. pallidum*

9. Penis lobes with terminal or subterminal spines (Fig. 167); black spiracular dots on terga 4-8 (Fig. 121); black dashes on face below antennae .... *S. candidum*
Penis lobes without terminal or subterminal spines (Fig. 170) but usually with discal spines; spiracular dots and black marks on face usually absent .... *S. carolina*

10. Cross veins in bulla region of fore wing crowded in first 6 interspaces (Fig. 153); discal spine of penis lobe about same size as apical spine (Fig. 172) .... *S. femoratum*
Cross veins in bulla region of fore wing crowded in just 3 interspaces (Fig. 154); discal spine on penis lobe much larger than apical spine and broadly triangular (Fig. 171) ... *S. tripunctatum*

11. Cross veins of fore wing crowded in first 6 spaces (Fig. 158) 12
Cross veins of fore wing crowded in first 3 spaces or not crowded at all (Fig. 163) ... 13

12. Abdomen dark yellow brown to medium brown; posterior ½ or more of terga 2-8 dark brown, this band sometimes nearly reaching anterior margin on meson (Fig. 136 and 137) .... *S. pudicum*
Abdomen light yellow brown to white with narrow brown band at posterior margin of each terga 2-8, this band usually narrowest at meson (Fig. 130) .... *S. carlsoni*

13. Terminal, subterminal, or discal, spines present on penis lobes 14
Terminal, subterminal, and discal spines of penis lobes absent 31

14. Apical spine on each penis lobe larger or about the same size as terminal, subterminal, or discal spine (Fig. 178) 15
Apical spine definitely smaller than terminal, subterminal, or discal spine (Fig. 184) 23

15. At least posterior half of terga 2-6 brown in mid-dorsal area; a wide, dark brown band at posterior margin (Fig. 135) .... *S. vicarium*
Dark band at posterior margin of terga 2-6 limited to a narrow line less than 1/5th width of terga 16

16. Dark gray longitudinal line on meson of terga 3 and 6 (Fig. 140); cross veins in bulla region and beyond arranged serially across wing usually forming elongate cells (Fig. 160); spiracular marks, if present, consist of black oblique streaks (Fig. 139) .... *S. integrum*
No dark gray longitudinal line on meson of terga 3 and 6; cross veins in bulla region and beyond not arranged serially across wing (Fig. 162); spiracular marks, if present, consist of black dots (Fig. 143) 17

17. Hind wing tip dark margined (Fig. 157 and 159) 18
Hind wing tip not dark margined (Fig. 164) 19

18. Spiracular dots present (Fig. 146) ... *S. smithae*
Spiracular dots absent .... *S. exiguum*

19. Spiracular dots present (Fig. 143) 20
Spiracular dots absent .... *S. terminatum*

20. Posterior margins of terga 2-8 with small black dash on meson as in Fig. 141 .... *S. mediopunctatum*
Posterior margins of terga 2-8 with narrow black crossline 21

21. Fore tarsal ratio 1.1-1.3; spines on penis lobes as in Fig. 174 .... *S. modestum*
Fore tarsal ratio 1.7-2.1 22

22. Penis lobes with subterminal spine smaller than apical spine (Fig. 178); cross veins not crowded in bulla region (Fig. 156); mesoscutellum entirely white .... *S. pulchellum*
Penis lobes with subterminal spine about same size as apical spine (Fig. 185); cross veins in bulla region with 2 or 3 veins present in at least two intervals (Fig. 164); only tip of mesoscutellum white .... *S. rubrum*

23. At least posterior half of terga 2-6 shaded with brown in mid-dorsal area (Fig. 131 and 147) 24
Abdominal terga pale except dark band at posterior margin covering much less than ¼th of segment (Fig. 138) 25

24. Fore wing with many cross veins forming short cells (Fig. 161); mesonotum and abdomen with distinct reddish brown cast .... *S. ithaca*
Fore wing normal with some elongate cells; mesonotum deep brown but without reddish cast .... *S. fuscum*

25. Posterior margins of terga 2-8 with a pair of short dashes (Fig. 133) .... *S. bipunctatum*
Posterior margins of terga 2-8 with narrow black lines or diffuse reddish band 26

26. Spiracular marks, if present, consist of oblique grey dashes (Fig. 142) 27
Spiracular black dots present 28

27. Penis lobes boot-shaped with subterminal spine (Fig. 188); mesonotum light yellow-brown; narrow black line at posterior margins of terga 2-6 (Fig. 144); oblique grey dashes may be present in spiracular area (Fig. 142) ... *S. luteum*
Penis lobes oval with large discal spine (Fig. 180); mesonotum dark brown; diffuse reddish band at posterior margins of terga 2-6; spiracular marks not present .... *S. placitum*

28. Narrow brown band at apex of hind wing (Fig. 138) .... *S. quinquespinum*
Hind wing without narrow brown band at apex (Fig. 162) 29

29. Large spine on penis lobe in discal position (discal spine) (Fig. 175) .... *S. annexum*
Large spine on penis lobe in terminal position (terminal spine) (Fig. 183) 30

30. Fore tarsal ratio more than 2.0; cross veins in bulla region moderately crowded .... *S. rubromaculatum*
Fore tarsal ratio less than 2.0; cross veins in bulla region not crowded (Fig. 162) .... *S. nepotellum*

31. Abdominal terga 3-8 each with a pair of submedian transverse black streaks at posterior margin (Fig. 129); mesonotum reddish brown; fore tarsal ratio about 2.0 .... *S. ares*
Abdominal terga 3-8 each with an unbroken narrow black line across posterior margin; fore tarsal ratio about 1.2 to 1.5 .... *S. lepton*

Characters for separating adults to species groups:

Character	Group		
	INTERPUNCTATUM	*FEMORATUM*	*PULCHELLUM*
Lateral spines on penis	yes (except *carolina)*	no	no
Cross veins in fore wing crowded	usually	yes	variable
Black dash or dot below bulla	yes	no	no
Costal cross veins of fore wing dark margined	yes	no	no
Markings on posterior margin of terga 1-8	dark line	3 dashes	variable
Eggs:			
with polar caps	yes	no	no
with sperm guide hoods	no	no	yes

Characters of *FEMORATUM* group adults:

Character	*S. femoratum*	*S. t. tripunctatum*	*S. t. scitulum*
Cross veins in bulla region crowded in	1st 6 spaces	1st 3 spaces	1st 3 spaces
Dark band on hind wing-tip	wide	absent	narrow
Length of forewing:			
Male	10-13mm	10-13mm	8-10mm
Female	13-17mm	13-17mm	9-11mm

Characters of *INTERPUNCTATUM* group adults:

Character	*S. carolina*	*S. candidum*	*S. floridense*	*S. gildersleevei*	*S. interpunctatum*	*S. minnetonka*	*S. pallidum*
Black mark on face below antennae	absent	dash	absent	line	variable	line	dash
Dark median line on sterna	absent	absent	absent	present	absent	absent	absent
Pleural streaks	absent	absent	absent	absent	variable	absent	absent
Stigmal dots	absent	present	absent	obscure	variable	present	absent
Black spot or dash below bulla of fore wing	spot	absent	dash	dash	dash	dash	spot
Penis lobes:							
Terminal spine	absent	present	absent	present	variable	absent	absent
Discal spine	present	absent	present	absent	variable	small	present
Lateral spine	absent	minute	present	present	present	present	present
Apical spine	present	minute	minute	absent	variable	large	minute
Axial spine	absent	absent	present	absent	absent	absent	absent
Fore tarsal ratio	1.8-2.0	2.0	2.0-2.4	1.5-2.5	1.1-3.5	2.0	2.0

Characters of *PULCHELLUM* group adults:

Species	Cross veins in bulla region	Spines[1] on penis lobes	Stigmal dots	Hind wing tip dark	Fore tarsal ratio	Posterior margin of tergites 2-7
S. annexum	2 or 3	A, D	present	no	1.6-1.9	narrow line
S. ares	1 or 2	A	absent	no	2.0	pair short dashes
S. bipunctatum	1 or 2	A, T	absent	no	1.5	pair short dashes
S. carlsoni	3-6	A	obscure	yes	1.5-2.0	narrow line
S. exiguum	1 or 2	A, T	absent	yes	1.3-1.9	narrow line
S. fuscum	1-3	A, T	obscure	no	2.0-3.0	segments ½ brown[2]
S. integrum	1-3	A, T	present	yes	1.3-2.0	narrow line
S. ithaca	1, 2, or 3	A, T	obscure	no	2.0-2.3	segments all brown[2]
S. lepton	1 or 2	A	absent	yes	1.2-1.5	narrow line
S. luteum	1 or 2	A, T	absent	no	2.1	narrow line
S. mediopunctatum	1 or 2	A, T	present	no	1.5-1.8	median dash
S. modestum	1 or 2	A, T	present	no	1.1-1.3	narrow line
S. nepotellum	1 or 2	A, T	present	no	1.5-2.0	narrow line
S. placitum	1 or 2	A, D	absent	no	1.8	diffuse band
S. pudicum	3-5	A, T	obscure	yes	1.5-2.0	wide band
S. pulchellum	1 or 2	A, T	present	no	1.7-2.1	narrow line
S. quinquespinum	1 or 2	A, D	present	yes	1.6	narrow line
S. rubromaculatum	2 or 3	A, T	present	no	1.6-2.2	narrow line
S. rubrum	1, 2, or 3	A, T	present	no	1.7	narrow line
S. smithae	1-3	A, T	present	yes	1.7-2.1	narrow line
S. terminatum	1 or 2	A, T	absent	no	1.5-2.5	vague band
S. vicarium	2-3	A, T	absent	no	2.5-4.0	wide band

[1] A=apical or subapical, D=discal, T=terminal or subterminal.

[2] In median area.

TABLE 2. LIST OF SPECIES OF *STENONEMA* AND SYNONYMS OF VARIOUS AUTHORS

Authors			
Lewis	**Burks**	**Traver**	**Spieth/Others**
INTERPUNCTATUM **GROUP**			
S. carolina (Banks)	*carolina*	*carolina*	*carolina*
S. candidum Traver	*candidum*	*candidum*	*interpunctatum frontale*
S. floridense Lewis	—	—	
S. gildersleevei Traver	*gildersleevei*	*gildersleevei*	*gildersleevei*
S. interpunctatum canadense	*canadense* (Walker)	*canadense*	*interpunctatum canadense*
S. interpunctatum canadense	*canadense*	*ohioense* Traver	*interpunctatum canadense*
S. interpunctatum canadense	*areion* Burks	—	—
S. interpunctatum frontale	*frontale* (Banks)	*frontale*	*interpunctatum frontale*
S. interpunctatum frontale	*frontale*	*majus* Traver	*interpunctatum frontale*
S. interpunctatum frontale	*canadense*	*proximum* Traver(1)	*interpunctatum frontale*
S. interpunctatum heterotarsale	*heterotarsale* (McD.)	*heterotarsale*	*interpunctatum heterotarsale*
S. interpunctatum interpunctatum	*interpunctatum* (Say)	*interpunctatum*	*interpunctatum interpunctatum*
S. interpunctatum interpunctatum	*heterotarsale* (McD.)	*affine* Traver (2)	*interpunctatum interpunctatum*
S. interpunctatum interpunctatum	*canadense*	*conjunctum* Traver	*interpunctatum frontale*
S. minnetonka Daggy	*minnetonka*	—	—
S. pallidum Traver	—	*pallidum*	*interpunctatum interpunctatum*
FEMORATUM **GROUP**			
S. femoratum (Say)	*femoratum*	*femoratum*	*femoratum femoratum*
S. tripunctatum tripunctatum	*tripunctatum* (Banks)	*tripunctatum*	*femoratum tripunctatum*
S. tripunctatum tripunctatum	—	*birdi* Traver	*femoratum tripunctatum*
S. tripunctatum scitulum	—	*scitulum* Traver	*femoratum scitulum*
PULCHELLUM **GROUP**			
S. annexum Traver	—	*annexum*	
S. ares Burks	*ares*	—	
S. bipunctatum (McD.)	*bipunctatum*	*bipunctatum*	
S. carlsoni Lewis	*pudicum* (Hagen)	*pudicum*	
S. exiguum Traver(3)	—	*exiguum*	*integrum*(4)
S. exiguum	—	*alabamae* Traver(5)	
S. fuscum fuscum (Clemens)	*fuscum*	*fuscum*	
S. fuscum rivulicolum	*vicarium*	*rivulicolum* (McD.)	
S. integrum integrum	*integrum* (McD.)	*integrum*	
S. integrum integrum	*integrum*	*bellum* Traver	
S. integrum integrum	*metriotes* Burks	—	
S. integrum wabasha	*integrum*	—	*wabasha* Daggy (1945)
S. ithaca (Clemens & Leonard)	*ithaca*	*ithaca*	
S. lepton Burks	*lepton*	—	
S. luteum (Clemens)	*luteum*	*luteum*	
S. mediopunctatum (McD.)	*mediopunctatum*	*mediopunctatum*	
S. modestum (Banks)	*modestum*	*Iron modestus*	
S. nepotellum (McD.)	*nepotellum*	*nepotellum*	
S. placitum (Banks)	*terminatum*	*placitum*	
S. pudicum (Hagen)	*pudicum*	*pudicum*	
S. pulchellum (Walsh)	*pulchellum*	*pulchellum*	
S. quinquespinum Lewis	—	*exiguum*	
S. rubromaculatum (Clemens)	*rubromaculatum*	*rubromaculatum*	
S. rubrum (McD.)	*rubrum*	*rubrum*	
S. rubrum	—	*varium* Traver	
S. smithae Traver	—	*smithae*	*smithae*(6)
S. terminatum (Walsh)	*terminatum*	*terminatum*	
S. vicarium (Walker)	*vicarium*	*vicarium*	

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(1) *Stenonema proximum* is probably the result of hybridization between the subspecies *frontale* to the east, *interpunctatum* to the south and west, and *canadense* to the north.

(2) Traver described *S. affine* in 1933 (1933a) and synonymized it with *S. heterotarsale* in 1935. Spieth (1947) synonymized *S. affine* with *S. interpunctatum* ss. but Burks (1953) incorrectly considered it a synonym of *S. heterotarsale*.

(3) Mouthparts and ecology described at length by Dr. Berner (1950).

(4) The nymph described by Leonard and Leonard (1962) as *S. integrum* is not that species as they suggested. Both the nymph and male imago that they described are probably *S. exiguum*, which is common in Michigan.

(5) Described in 1937 from a single male and a few females collected from a store window at Sheffield, Alabama.

(6) Berner (1950) described the mouthparts and reported on the ecology of this species.

Stenonema annexum Traver

(Figures 96, 110, 175)

Stenonema annexum Traver, 1933: 179; Traver, 1935: 304

NYMPH: Length 10-11 mm.

Head: Reddish brown, lateral areas pale, vertex with large pale diamond-shaped area; *maxilla* with 4 or 5 pectinate spines and 25-30 setae on crown, 20-25 lateral setae; *mandibles* with 6 or 7 teeth on inner margin of each outer canine (Fig. 96).

Thorax: Reddish brown with small pale spots at base of wing pads; *legs* wth 3 irregular dark brown transverse bands on dorsal surface of femora, claws pectinate near tips (Fig. 110).

Abdomen: Reddish brown dorsally with many minute pale dots and a dark median stripe extending length of abdomen; *terga* 4, 5, and 8-10 dark with irregular pale anterior margins, tergum 7 pale with median dark line; *sterna* pale with yellowish-red shading, sometimes with brownish oblique lateral marks on sternum 9; *gills* 1-6 truncate at apices, 7th finger-like gill with a fringe of hairs but without tracheae; *postero-lateral angles* of segments 7 to 9 extended as short spines; *caudal filaments* pale with brown shading on basal segments.

MALE IMAGO: See Traver (1935) for complete description.

Genitalia (Fig. 175).

ECOLOGY AND DISTRIBUTION

Very little is known of the ecology of this species. It has been collected in headwater streams and is probably a clean-water form.

The known distribution forms a narrow band from eastern North Carolina southward to Alabama then northward to southern Indiana (Fig. 189).

Specimens Examined: GEORGIA — Ichawaynochaway Creek, Morgan, 4IV46, 1 male (Fattig). INDIANA — Sand Creek, Reddington, 13X65, 1 nymph (Anderson); White River, Newberry, 14X65, 1 nymph (Anderson). KENTUCKY — W. Fork Drakes Creek, Franklin, 21V71, 1 male (Myers). NORTH CAROLINA — Fear River, Buies Creek, 1IV30, 1 nymph (Traver); Goshen Swamp, 11VI29, 1 male (Holotype) (Needham).

DISCUSSION

Traver (1933a) suggested that *S. annexum* is near *S. rubromaculatum* and *S. mediopunctatum;* however, the genitalia are not very similar to either species.

Differences between *S. annexum* and *S. rubrum* nymphs appear to be limited to the amount of dark coloration on the terga and sterna. There are slight differences in the male genitalia, and the fore tarsal ratio of *S. rubrum* is 1.7 compared with 2.0 for *S. annexum.* Since I have not reared either of these species and it is not known if the differences in genitalia and leg ratio are constant, they are treated here as separate species.

Stenonema ares Burks

(Figures 69, 95, 115, 129)

Stenonema ares Burks, 1953: 170

NYMPH: Length 10 mm.

Head: Light brown, freckled with numerous white dots, three large white spots on lateral margin near each compound eye; base of antennae dark, remainder white; *maxilla* with 2 to 4 pectinate spines but without setae on crown, 15-25 lateral setae (Fig. 69); *mandibles* with 6 or 7 teeth on inner margin of each outer canine (Fig. 95).

Thorax: Light brown with many irregular white spots; *legs* with basal and median brown band on each tibia, tarsi brown except base and apex, claws not pectinate (Fig. 115).

Abdomen: *Terga* 1-5 mostly white, 6-8 mostly brown, 9 brown on meson and near lateral margins, and 10 brown except for two submedian basal white spots; *sterna* white except sternum 9 that sometimes has vague lateral and basal brown marks; *gills* 1-6 truncate at apices, 7th finger-like gill with a fringe of hairs but without tracheae; *postero-lateral angles* of segments 7-9 extended as spines; *caudal filaments* pale, apical articulations slightly shaded with tan.

MALE IMAGO (Fig. 129): See Burks (1953) for original description and figure of genitalia.

ECOLOGY AND DISTRIBUTION

Little is known concerning the ecology of this species. Nymphs of *S. ares* and larvae of the caddisfly, *Hydropsyche orris* Ross were collected from the Wabash River from rubble substrate in moderately swift current. There was evidence of enriched conditions prevailing in the river (pH 8.0, TDS 330 mg/l) at the time of collection (New Harmony, Indiana, 8/14/63). During the following summer, the mayflies and caddisflies were replaced by bloodworms, *Glyptotendipes* sp. (10,000/ft^2), indicating that degrading changes in environmental conditions had eliminated the *S. ares* nymphs. However, Leonard (1965) found *S. ares* nymphs in a stream where copper and cyanide concentrations had caused complete fish kills, and Simmons and Winfield (1971) found that the species was little affected by siltation.

This species is sympatric with *S. bipunctatum* over most of Illinois and appears to be common in the Wabash drainage system in Indiana (Fig. 189). It is surprising that the species has not been reported from Wisconsin, because it is common in the northern counties of Illinois (Burks, 1953).

Specimens Examined: ILLINOIS — Shoal Creek, Greenville, 12IV46, 1 male (Paratype) (Mohr and Burks); same location, 11VI46, 1 nymph (Mohr and Burks); Muddy Creek, Jewett, 17IV46, 2 nymphs (Mohr and Burks); Rock River, Rockford, 22V41, 1 male (Ross and Burks). INDIANA — Great Miami River, Lawrenceburg, 15VII71, 1 nymph (Lewis); Wabash River, New Harmony, 14VIII63, 1 nymph (Lewis); same location, 15VII66, 1 nymph (Lewis); same location 9XI66, 1 nymph (Lewis).

DISCUSSION

Adults of this species are easily confused with *S. bipunctatum.* The only reliable character for separating the two species is the absence of either discal or terminal spines on the penis lobes of *S. ares* compared with the penis lobes of *S. bipunctatum,* which are armed with prominent terminal spines (Fig. 187). Nymphs of *S. terminatum* and *S. integrum* would also key to *S. ares* in Burks' (1953) key; therefore, reports in past literature concerning this species should be confirmed before using the data.

Stenonema bipunctatum (McDunnough)

(Figures 33, 90, 133, 187)

Ecdyonurus bipunctatus McDunnough, 1926: 191

Stenonema bipunctatum Traver, 1935: 306; Daggy, 1945: 374; Burks, 1953: 169

NYMPH (Fig. 33): Length 10 mm.

Head: Light brown, thickly sprinkled with fine yellow dots, pale areas around ocelli and lateral to compound eyes; base of antennae dark brown, remainder paler; *maxilla* with 2 to 4 spines but without setae on crown, 20-25 lateral setae; *mandibles* with 5 or 6 teeth on inner margin of outer canine (Fig. 90).

Thorax: Reddish-brown with a few fine pale dots, pronotum with three larger pale spots in each anterolateral angle; *legs* with two irregular pale bands on femora surrounded by a thick sprinkling of dark brown freckles, tibiae and tarsi mostly pale, claws usually pectinate.

Abdomen: Reddish-Brown, thinly sprinkled with pale dots; *terga* pale at anterolateral angles, posterior margin of tergum 10 blackish, often paired dark submedian dashes of adult shows through integument; *sterna* variable as to amount of dark coloration, sterna 2-8 usually with paired submedian, posteriorly divergent dashes, 9 with wide dark band around outer margin leaving center of sternum pale; *gills* 1-6 truncate at apices, 7th gill fingerlike with a fringe of hairs and without tracheae; *posterolateral angles* of segments 4-9 usually extended as spines; *caudal filaments* banded with light and dark areas.

MALE IMAGO (Fig. 133): See Burks (1953) or Traver (1935) for description.
Genitalia with a large terminal spine and small apical spine on each penis lobe (Fig. 187).

ECOLOGY AND DISTRIBUTION

S. bipunctatum nymphs inhabit unpolluted reaches of rivers and larger streams. They are usually near, but seldom found in, swift current. The distribution of this species is restricted to the Great Lakes Region and Upper Mississippi Valley in the United States, and extends northward through central Canada (Fig. 190).

Specimens Examined: ILLINOIS — Nippersink Creek, Spring Grove, 14VI38, 1 female (Burks). NEW YORK — Niagara Falls, 29VII30, 2 males (Paratypes) (Walley); Susquehanna River, Binghamton, 5VII69, 1 female (Lewis). WISCONSIN — Clam River, Burnett Co., 3VI72, 1 male (reared) (Flowers). CANADA — Assiniboine River, Winnipeg, Manitoba, 11VII68, 4 males, 1 female (Flannagan); Pelee Island, Ontario, 3VII31, 1 male (Walley); Niagara Falls, Ontario, 28VII25, 1 male (Holotype) (Walley).

DISCUSSION

This species has previously been confused with *S. ares* in both adult and nymph. Previous adult keys were based on color characters and differences in the ratio of the second fore tarsal segment to the first. Examination of the types has revealed that *S. ares* lacks discal or terminal spines on the penis lobes, whereas *S. bipunctatum* has large terminal spines (Fig. 187). Nymphs have not been positively associated with adults by rearing, but those currently recognized as this species differ from *S. ares* in having pectinate claws and posterolateral spines on abdominal segments 4-9 rather than only on 7-9 as in *S. ares.* The amount of variation of these characters infraspecifically is not known. Since no intergrades have been collected, Burks' (1953) description of *S. ares* as a new species is considered sound.

Two nymphs and a reared female imago from the Little Miami River at Milford, Ohio, are tentatively placed here until a male is available for comparison with the types. The female is similar to *S. ares* except that the mesonotum is light clay-colored as in *S. bipunctatum* rather than reddish-brown. These two nymphs differ from what is presently considered to be the nymph of *S. bipunctatum* in having 5-6 spines and 1-2 setae on the crown of the maxillae and the tarsal claws are not pectinate.

Stenonema candidum Traver

(Figures 15, 55, 82, 121, 152, 167)

Stenonema candidum Traver, 1935: 308; Burks, 1953: 162
Stenonema interpunctatum frontale Spieth, 1947: 109 (unjustified synonymy)

NYMPH: Length 8-9 mm.
Head: Light brown, without a pale spot at frontal margin, triangular white mark near anterior ocellus; *maxilla* with 7 or 8 pectinate spines but without setae on crown, 15-25 lateral setae (Fig. 55); *mandibles* with 8 teeth on inner margin of outer canine of left mandible and 5 or 6 on right mandible (Fig. 82).
Thorax: Light brown except on median line, a pair of large sublateral white spots on pronotum; *legs* brown, each femur with a basal, median, and apical white crossband, each tibia white near base and at apex, claws not pectinate.
Abdomen: Light brown; *terga* with a pair of narrow discontinuous submedian white lines (Fig. 15); *sterna* white, lateral margin of sternum 8 and lateral and posterior margins of 9 brown; *gills* 1-6 pointed at apices, 7th gill fingerlike with tracheae but without a fringe of hairs; *posterolateral angles* of segments 7-9 extended as spines; *caudal filaments* white with alternating faint brown articulations.

MALE IMAGO (Fig. 121): See Burks (1953) or Traver (1935) for complete description.
Genitalia with lateral spines minute or apparently absent (Fig. 167).

ECOLOGY AND DISTRIBUTION

This species is widely distributed throughout the midwest but is rare in collections (Fig. 191). Most specimens known to be this species are from springs or cold clear streams. Bender and Eisele (1971) established a 96-hour TL_{50} value of 2.10 $\mu g/l$ for methoxychlor using *S. candidum* nymphs as test animals.

Specimens Examined: ILLINOIS — Belle Smith Spring, Eddyville, 7VI46, 1 male (Mohr and Burks); Lusk Creek, Eddyville, 6VI46, 2 males (Mohr and Burks). KENTUCKY —W. Fork Drakes Creek, Franklin 20V71, 1 male (Myers). OHIO — Chagrin River, Pleasant Valley, 24VIII33, 1 male, 1 nymph (Paratype) (Traver); same location, 23VII34, 1 female (Allotype) (Traver); Willoughby, 23VI34, 1 male (Holotype) (Traver).

DISCUSSION

Spieth (1947) synonymized this species with *S. interpunctatum frontale,* postulating that Traver had either mislabeled the genitalia of *S. carolina* as this species or that the holotype was an aberrant individual. However, neither Burks nor Edmunds accepted Spieth's synonymy, and an examination of the holotype and allotype has convinced me that *S. candidum* is distinct from *S. interpunctatum.* Furthermore, a reared male of this species from Drakes Creek, Kentucky, and a male from Eddyville, Illinois, are similar to the type, and Daggy collected a male and 5 females from Minnesota which Traver confirmed as this species. It is unlikely that the same aberration would occur so regularly over such a wide area.

Nymphs of *S. candidum* differ from *S. interpunctatum frontale* in having 7 or 8 pectinate spines on the crown of each maxilla compared with 9 for *S.i. frontale,* the left mandible has 8 teeth on the inner margin of each outer canine compared with 6 or 7 for *S. i. frontale,* and the abdomen lacks the dark markings on sterna 2-7 so characteristic of *S. i. frontale.* The nymph of *S. candidum* also lacks a pale spot on the frontal margin of the head which *S. i. frontale* nymphs usually possess. Characters used in the nymphal key are based on a slide-mounted exuvia from Cornell University Museum labeled "paratype" #1342.3.

Male imagos are easily distinguished by the genitalia (Fig. 167), which characteristically possess minute lateral spines. Cross veins in the bulla region are less crowded in this species than in related species, and they are not connected by a black dash (Fig. 152).

Stenonema carlsoni Lewis

(Figures 64, 107, 130)

Stenonema carlsoni Lewis, 1974: 347

NYMPH: Length 12-14 mm.

Head: Dark brown, freckled with pale dots, area lateral to eyes pale; *maxilla* with 7-9 pectinate spines but without setae on crown, 25-45 lateral setae (Fig. 64); *mandibles* each with 8-10 teeth on inner margin of outer canine (Fig. 107).

Thorax: Dark brown, pronotum with large pale spots near lateral margins; *legs* dorsally with 3 irregular dark bands and three white bands on femora, tibiae pale with basal and median brown bands, basal half of each tarsus dark, remainder pale, claws not pectinate.

Abdomen: Dorsum pale tan with broken median dark line on segments 2-8; *terga* 1, 8, and 9 mostly pale in median area, terga 2-5 and 7 with large pale submedian areas set off by brown lateral patches and median dark brown line, terga 6 and 10 mostly dark brown; *sterna* pale with faint dots and bars barely visible in median area of segments 2 to 9, sometimes lateral dark shading near margins of sternum 9; *gills* 1-6 truncate at apices, 7th gill with fringe of hairs but lacking tracheae; *posterolateral angles* of segments 3-9 extended as spines; *caudal filaments* uniformly tan with ring of stout black setae at articulations.

MALE IMAGO: Length 10-12 mm.

Head: Reddish brown, ocelli black-ringed at bases, usually a black or purple transverse line across face ventral to antennal sockets.

Thorax: Dark brown with reddish cast, mesonotum lighter yellow-brown; *mesoscutellum* dark brown; *legs* yellowish-tan, wide dark median and apical bands on each femur, remainder of legs mostly pale tan with dark shading near joints, fore tarsal ratio 1.5-2.0 (ratio of length of 2nd tarsal segment to length of 1st); *fore wing* hyaline with cross veins crowded in bulla region in first 6-8 interspaces forming a dark curved streak across wing, reddish brown stain in stigmatic area in costal and subcostal interspaces, elongated cells in discal area proximal to bulla region; *hind wing* with wide brown band at apical margin (Fig. 130).

Abdomen: Tawny with brownish lateral areas and narrow black or brown posterior margins on each tergum; *genitalia* distinctly boot-shaped, penis lobes with straight apical margins, apical spines minute, terminal spines large; *caudal filaments* yellowish white, articulations brown.

ECOLOGY AND DISTRIBUTION

This species is common in Georgia and South Carolina where it apparently replaces the closely related *S. pudicum* in mountain streams (Fig. 190). Nothing is known of its pollution tolerance but its distribution indicates that a clean water habitat is preferred.

Specimens Examined: GEORGIA — University Creek, Athens, 2IV49, 1 female, 1 nymph (Rickert and Scott). KENTUCKY — Pine Mt. State Park, 18VI58, 1 nymph (Peters). SOUTH CAROLINA — Eighteen Mile Creek, Route 56, 1VI66, 1 nymph (Prins); Wildcat Creek, Pickens Co., 11III67, 1 male (reared) (Carlson).

DISCUSSION

Probably most specimens from South Carolina and Georgia labeled "*S. pudicum*" are this species, which was recently described by Lewis (1974). Superficially, they are quite similar in both nymph and adult. *S. carlsoni* can be distinguished from *S. pudicum* by the following characters: in the nymph, the crown of the maxilla lacks setae but is armed with 7-9 pectinate spines, whereas *S. pudicum* has 20-40 crown setae in addition to the 5-8 pectinate spines; adults lack the dark sagittate mark in the median area of each tergum so characteristic in *S. pudicum* and the dark posterior margin of each tergum is much narrower than in *S. pudicum*; there are also noticeable differences in the arrangement of spines on the penis lobes.

Stenonema carolina (Banks)

(Figures 17, 54, 84, 119, 148, 170)

Heptagenia carolina Banks, 1914: 616

Stenonema carolina Traver, 1933: 197 (misidentified); 1935: 309; Spieth, 1947: 102; Burks, 1953: 161

NYMPH (Fig. 17): Length 10-12 mm.

Head: Uniform brown; *maxilla* with 10 heavy pectinate spines on crown, crown setae absent, 20-30 lateral setae (Fig. 54); *mandibles* each with 7 or 8 teeth on inner margin of outer canine, left mandible with 2 prominent blunt teeth on inner margin of inner canine (Fig. 84).

Thorax: Uniform brown; *legs* with femora uniform brown dorsally, pale below, each tibia with 2 broad pale bands each side of middle, claws not pectinate.

Abdomen: Almost uniformly brown; *terga* each with a pair of short narrow submedian pale streaks at anterior margin; *sterna* uniformly light gray-tan without darker markings; *gills* 1-6 pointed at apices, 7th gill without fringe of hairs but with distinct tracheae; *posterolateral angles* of segments 7-9 extended as spines; *caudal filaments* gray throughout.

MALE IMAGO (Fig. 119): See Burks (1953) or Spieth (1947) for description.

Fore wing with cross veins in bulla region not usually connected by black dash (Fig. 148); *genitalia* with small apical and discal spines (Fig. 170).

ECOLOGY AND DISTRIBUTION

Nymphs of *S. carolina* inhabit the cold, clear mountain streams of the Appalachian Mountains from South Carolina and Georgia to Quebec, Canada (Fig. 191).

Specimens Examined: NORTH CAROLINA — S. Fork, Swannanoa River, Black Mt., 1 male, 1 female (Paratypes #1144) (Banks); Catawba River, Swannanoa (Type locality) 18VI30, 1 female (reared) (Traver); Catawba River, Black Mt., 31V12, 1 male (Beutenmuller); same location, 18VI29, 1 male, 2 females (Traver); Davidson River, Pisgah Forest, 20VI26, 1 female (Thompsen); Nolichuky River, Cranberry, 8VI36, 1 female (Traver). SOUTH CAROLINA — Keonee River, Clemson, 29IV33, 2 males, 1 female (Dunavan); Reedy River, Greenville, 1IX32, 1 male, 1 female (Townes). TENNESSEE — Chimneys Campground, Smoky Mt. National Park, 24VI39, 3 males; W. Branch Little Pigeon River, Gatlinburg, 14VIII29, 1 male (Needham). WEST VIRGINIA — Moores Creek, Wardenville, 15VIII30, 1 male, 3 females (Traver). CANADA — Covey Hill, Quebec, 17VI27, 1 male (Walley).

DISCUSSION

Traver's (1933) description of the nymph of this species was based on misidentified specimens of what she later described as *S. candidum* Traver. A male and two females in the Cornell collection that she collected at Wardensville, West Virginia, and labeled "*S. candidum* Traver" appear to be *S. carolina*.

The specimens from Covey Hill, Quebec, have terminal spines on the penis lobes while those from North Carolina have discal spines, but in other characters, the two populations are similar. Probably the Canadian population is sufficiently different to warrant subspecies status.

A female subimago from Sand Creek, Scipio, Indiana, 6V70, and a nymph from Wildcat Creek, Indiana, 5VIII69, seem to belong to this species, but this needs confirmation by additional collecting and rearing from these areas.

Stenonema exiguum **Traver**

(Figures 23, 63, 94, 117, 157)

Stenonema exiguum Traver, 1933: 201; 1935: 310; Daggy, 1945: 374; Berner, 1950: 70
Stenonema alabamae Traver, 1937: 79 NEW SYNONYMY

NYMPH (Fig. 23): Length 9-11 mm.

Head: Brown, heavily sprinkled with fine white dots, pale area between each compound eye and lateral ocellus, a pale hat-shaped area anterior to median ocellus, pair of pale spots lateral to each compound eye divided by a brown band; basal antennal segments dark brown, flagellum brown at base, paler distally; *maxilla* with 4 to 9 pectinate spines but without setae on crown, 18-25 lateral setae (Fig. 63); *mandibles* each with 6-8 teeth on inner margin of outer canine (Fig. 94).

Thorax: Brown with scattered pale dots, pronotum with sublateral pale spots near each anterior margin and at lateral margins, a transverse pale band across mesonotum at base of wing pads; *legs* brown sprinkled dorsally with many dark brown spines, each femur with three irregular pale bands, tibiae and tarsi largely yellowish, claws pectinate (Fig. 117).

Abdomen: Amount of brown and white (or yellow) quite variable among specimens; *terga* 1-3 and 7 largely pale except in darkest specimens, terga 4 and 5 typically brown with a pair of submedian and sublateral pale areas (about evenly brown and white), terga 6 and 8-10 mostly dark brown, 10 often blackish; *sterna* almost entirely white or yellow except segment 9 which has brown posterolateral angles; *gills* 1-6 truncate at apices, 7th gill with fringe of hairs but without a trachea; *posterolateral angles* of segments 7-9 extended as spines; *caudal filaments* alternately banded with white or yellow and brown.

MALE IMAGO: See Traver (1935) for a complete description.

Hind wing often with faint brown shading as in Fig. 157; *genitalia* with apical and terminal spines of penis lobes about equal in size.

ECOLOGY AND DISTRIBUTION

Nymphs of this species are seldom found in smaller streams but occupy the larger creeks and rivers with sandy bottoms; they live on rocks, logs or other objects anchored in the sand. Berner (1950) collected a nymph from a depth of 15 feet in a sand bottomed lake with an Ekman grab, further substantiating its preference for sandy substrate. Beck (1954) listed *S. exiguum* as a class I organism, the presence of which indicates that the water in which they are found has not been appreciably altered by organic pollutants. However, Berner (personal correspondence) has recently collected these nymphs from the shores of a highly enriched lake in Florida and I have collected them from the Ohio River in the mesotrophic zone.

This species appears to be abundant in Florida, Alabama, and Georgia; rare from North Carolina and Tennessee to Indiana and Illinois; and again becomes abundant in Michigan, Minnesota, and Wisconsin (Fig. 192).

Specimens Examined: ALABAMA — Sheffield, 4VII36, 2 females, 1 male (Types of *S. alabamae* Traver). GEORGIA — Oostanaula River, Rome, 15VII39, 2 males (Fattig); Etowah River, Rome, 16VIII31, 1 male (Paratype) (Fattig). INDIANA — Ohio River, Madison, 30VII68, 1 nymph (Lewis.) NORTH CAROLINA—Woodlawn, 16VII30, 1 male (Holotype) (Traver). WISCONSIN—Oconto River, Oconto Co., 28V69, 1 nymph (Hilsenhoff).

DISCUSSION

This species is quite distinctive in both nymph and adult and is likely to be confused with only one other species, *S. quinquespinum*, from which it can be separated as discussed under that species. There are a southern form and a northern form, which are probably subspecies. The southern form, smaller and paler than the northern form, is very common in Florida, Alabama, and Georgia. The northern form is common in Minnesota, Michigan, and Wisconsin. The nymphs from Michigan that Leonard and Leonard (1962) tentatively placed as *S. integrum* are probably this species. Nymphs have been collected also from several scattered locations in the Ohio River Basin, principally from the Ohio River at Madison, Indiana. The wide gap in distribution cannot be explained from existing data.

S. alabamae, which is known only from the type series, differs from *S. exiguum* only in having the first fore tarsal segment "fully three-fourths as long as the second." The range of the fore tarsal ratios in recently examined specimens of *S. exiguum* from Wisconsin includes the ratios given for *S. alabamae*. The genitalia were missing from the types and the nymphs are unknown at present.

For the reasons stated above *S. alabamae* is considered to be a junior synonym of *S. exiguum*.

Stenonema femoratum **(Say)**

(Figures 10, 11, 18, 38, 58, 87, 128, 153, 172)

Baetis femorata Say, 1823: 162
Ecdyonurus femoratus McDunnough, 1925: 190
Stenonema femoratum Traver, 1935: 311; Burks, 1953: 169
Stenonema femoratum femoratum Spieth, 1947: 98

NYMPH (Fig. 18): Length 9-12 mm.

Head: Brown freckled with pale dots, anterior margin with median indentation (emarginate), never with anteromedian white spot: *maxilla* with 2 pectinate spines and 2-16 setae on crown, 30-40 lateral setae (Fig. 58); *mandibles* each with 5-7 teeth on inner margin of outer canine (Fig. 87).

Thorax: Light brown with scattered yellow or white blotches either side of middle; *legs* with femora mostly brown with white spots and covered with dark brown spines, tibiae and tarsi pale tan, claws pectinate.

Abdomen: Light brown or tan with large pale "X-shaped" mark extending over *terga* 7-9 and a smaller "X-shaped" spot on tergum 5 usually present; *sterna* 5-8 each pale usually with a pair of light brown spots near lateral margins, sterna 1-4 usually pale without darker markings, posterior half of sternum 9 brown (Fig. 38) (occasionally brown border is reduced to large brown spots, in which case tergum 9 would have 2 pairs of brown spots, or all ventral brown spots may be absent); *gills* 1-6 rounded at apices

(Fig. 10), 7th gill with tracheae and fringe of hairs (Fig. 11); *posterolateral angles* of segments 2-9 produced as large spines; *caudal filaments* deep yellow at base, alternating pairs of segments light and dark in middle and apical areas.

MALE IMAGO (Fig. 128): See Traver (1935) or Burks (1953) for complete description; Spieth's (1947) description is even more detailed than Traver or Burks.

Fore wing with cross veins crowded in bulla region in first 6 interspaces, dark shading present in bulla region; *hind wing* with very wide dark band at apical margin (Fig. 153); *genitalia* with apical and discal spines about same size and shape (Fig. 172).

ECOLOGY AND DISTRIBUTION

Nymphs of *S. femoratum* are common in small, cool streams east of the Mississippi River and south of the Great Lakes to Georgia and South Carolina (Fig. 193). One stream from which the author collected and reared nymphs received effluents from a small sewage treatment plant. The mean yearly TDS for 1969 was 450 mg/l and the mean TDP was 1.5 mg/l. The mean yearly DO was 9.8 mg/l, and the pH ranged from 7.5 to 8.0. Gaufin and Tazwell (1952) found *S. femoratum* nymphs inhabiting the recovery zone of Lytle Creek, Ohio, where the DO was often reduced below 2 ppm at night. This is probably one of the most tolerant mayflies to organic pollution; in fact, it seems to prefer waters high in dissolved solids and organic enrichment.

Specimens Examined: ILLINOIS — Herod, 23V46, 1 male (Ross and Mohr); Oakwood, 7V36, 1 male (Ross and Mohr). INDIANA — Salamonie River, Pennville, 25V66, 1 nymph (Anderson); St. Leon, 23IV69, 3 females (reared) (Lewis). KENTUCKY — Paint Lick Creek, Kirksville, 15VIII69, 1 nymph (Lewis); Little Kentucky River, Carrollton, 13VIII69, 1 nymph (Lewis). OHIO — E. Branch Chagrin River, Kirtland, 22IX32, 1 nymph (Traver); Kain Run, Williamsburg, 18V71, 1 female (Lewis); same location, 27V71, 2 females (reared), 1 male (reared) (Lewis); same location, 18V71, 2 females (reared) (Lewis); Shayler Run, Union Township, 2VI70, 1 nymph (Lewis), same location, 14IV71, 1 male (reared) (Lewis); same location, 23IV71, 1 male (reared) (Lewis).

DISCUSSION

Although Spieth (1947) believed that this species commonly intergrades with *S. tripunctatum* and reduced it to subspecies, I have found nymphs of both species inhabiting the same stream pools with little evidence of hybridization. A total of 24 nymphs from Shayler Run, Ohio, were reared to adults. Only 3 female imagos reared from *S. tripunctatum* nymphs showed any *S. femoratum* characteristics and these were only minor color characteristics. None of the *S. femoratum* nymphs reared out with *S. tripunctatum* characteristics. Therefore, *S. femoratum*, at least in the Ohio River Basin, is a monotypic species exhibiting very limited sympatric hybridization.

Stenonema floridense Lewis

(Figure 166)

Stenonema floridense Lewis, 1974: 350

NYMPH: Length 8-10 mm.

Head: Uniform brown anterior to compound eyes and on vertex, usually small median white spot at anterior margin, larger white spots lateral to compound eyes; *maxilla* with 8 or 9 heavy comb-like spines on crown but without crown setae, 20-25 lateral setae; *mandibles* each with 7 teeth on inner margin of outer canine.

Thorax: Uniform brown except for 4 white spots on pronotum, 1 near each anterolateral angle, 1 each at anterior margin midway between meson and lateral margin, a few small white dots on mesonotum at base of wing pads; *legs* brown dorsally each femur with 3 irregular rows of white spots, these spots much larger on fore legs and middle legs than on hind legs, venter mostly pale, claws not pectinate.

Abdomen: Mostly brown, an interrupted row of elongated white spots either side of meson; *terga* 1-4 and 9 with these narrow elongate spots nearly continuous as pale lines, tergum 8 with these white spots meeting so that mid-dorsal area is mostly white, other terga without submedian white spots, terga 2-7 each with white spots at lateral margins and midway between lateral margins and meson; *sterna* 1-8 mostly pale, sternum 9 (and sometimes 8) with lateral brown bands; *gills* 1-6 pointed at apices, 7th gill with tracheae but without a fringe of hairs; *posterolateral angles* of segments 7-9 extended as spines; *caudal filaments* very light brown.

MALE IMAGO: Length 7-9 mm.

Head: Pale yellowish white, ocelli black ringed at bases, typically face below antennal sockets is without black markings, but faint black dots, dashes or an unbroken line may be present; reddish-brown shading and gray dots on vertex.

Thorax: Light yellow-brown, two black streaks on pronotum; *mesoscutellum* white; *legs* greenish-yellow or white, faint reddish-brown median and apical bands on femora, median band usually missing from hind femur, apex of tibia brown, fore tarsal ratio 2.0-2.4; *fore wing* hyaline, dark dash at bulla sometimes connecting 2 or more cross veins, sometimes this dash reduced to small dot; *hind wing* with dark apical margin.

Abdomen: Hyaline with narrow black line at posterior margin of each tergum, no spiracular dots, alabaster white pigment on dorsum of segments 8 and 9; *genitalia* (Fig. 166) with large lateral spines and 2 to 4 large curved axial spines that may be three-lobed, apical spine minute or apparently lacking, discal spine as in *S. interpunctatum; caudal filaments* light gray throughout.

ECOLOGY AND DISTRIBUTION

This species is common in the panhandle of Florida and is the only species of the *INTERPUNCTATUM* group found in the sandy bottomed Blackwater River Basin of Santa Rosa and Okaloosa Counties. The streams in this basin are relatively swift and keep the shifting sand in almost constant motion. Most of the normal flow is ground water which is extremely soft, slightly mineralized, and low in dissolved nutrients. Beck (1973) reported pH ranges from 5.0-6.3, TDS ranges from 15-17, and DO ranges from 6.8-9.7.

Probably *S. floridense* is restricted to the naturally acid streams of the southeast that have not been effected by pollution (Fig. 190).

Specimens Examined: FLORIDA — Blackwater River, Blackman, 1V70, 1 male, 4 females (Allotype) (Peters); same location, 27IV72, 1 nymph (Peters); Blackwater River, Holts, 21IV72, 4 males (Holotype and Paratypes) (Peters); same location, 9IV71, 1 male (Paratype) (Peters); same location, 17VI71, 1 nymph (Peters); same location, 28IV72, 2 males, 1 female (Paratypes) (Peters), same location 8V71, 2 males (Peters); same location, 21IV68, 1 male (Beck); Comfort Creek, Quincy, 16IV67, 1 male (Peters); Chipola River, Calhoon Co., 12IV72, 1 male (Carlson); Holmes Creek, Brock Crossroad, 23IV67, 1 male (Peters); Rocky Comfort Creek, Gadsden Co., 1 male (Paratype) (Jones).

DISCUSSION

This species superficially resembles *S. interpunctatum* in both adult and nymph; however, the armature of the male genitalia is distinctly different from that of any related species (Fig. 166). None of the specimens examined showed any trace of black pleural streaks or black spiracular spots; otherwise color characters vary considerably as in *S. interpunctatum*.

Nymphs can usually be separated from *S. interpunctatum* by the presence of 8 pectinate spines on the crown of the maxilla. Nymphs, which occasionally have 9 spines on the crown of each maxilla as in many *S. interpunctatum*, are separated by the following combination of characters: 7 teeth on inner margin of outer canine, 4 teeth on inner margin of inner canine, less than 25 lateral setae on maxilla, and dorsal color pattern of interrupted elongate pale spots.

Stenonema fuscum (Clemens)

(Figures 29, 46, 75, 101, 132, 147, 184)

Heptagenia fusca Clemens, 1913: 254
Ecdyonurus fuscus McDunnough, 1933: 35 (redescription)
Stenonema fuscum Traver, 1935: 314; Burks, 1953: 173
Stenonema rivulicolum McDunnough, 1933: 40; Traver, 1935: 328 NEW COMBINATION

NYMPH (Fig. 29): Length 10-12 mm.

Head: Mostly brown with freckles of pale dots, pale spots at posterior margin and lateral to compound eyes; *maxilla* with 2-4 pectinate spines and 10-40 setae on crown, 25-35 lateral setae (Fig. 75); *mandibles* each with 7 or 8 teeth on inner margin of outer canine (Fig. 101).

Thorax: Mostly brown with pale spots near anterior and lateral margins of prothorax; *legs* brown dorsally with 3 irregular pale bands across each femur, mostly pale ventrally, claws not pectinate.

Abdomen: Mostly dark brown, *terga* darkest at posterior margins, *sterna* 1-8 each with a broad, transverse crossband at posterior margin, sternum 9 with a large brown spot at each posterolateral angle (Fig. 46); *gills* 1-6 truncate at apices; 7th gill with fringe of hairs but without tracheae; *posterolateral angles* of segments 3-9 extended as spines; *caudal filaments* uniformly tan in basal area, alternating pairs of segments dark and light distally.

MALE IMAGO (Fig. 147): See Traver (1935) for complete description. Burks' (1953) description is adequate, except that the genitalia of this species is shown in his figure 344 rather than his figure 346 which is the genitalia of *S. vicarium*.

Genitalia of the holotype are shown in Fig. 184.

ECOLOGY AND DISTRIBUTION

S. fuscum seems to be rare in the Ohio River Basin, it becomes more common north and west of the Great Lakes (Fig. 194). Nymphs inhabit riffle areas in rivers and larger streams.

Specimens Examined: MICHIGAN — Boardman River, Kalkaska Co., 18III71, 1 nymph (Meier); Little Manistee River, Irons, 28V39, 1 nymph (Burks); Platte River, Honor, 27V39, 2 males (Frison and Ross); Rapid River, Kalkaska Co., 18III71, 1 nymph (Meier). MINNESOTA — Baptism River, Finland, 29X64, 1 nymph (Bell); Devil Track River, Gunflint Trail, Cook Co., 31V65, 1 nymph (Lemke); Splitrock River, Hyway 3, Lake Co., 29X64, 1 nymph (Bell). WISCONSIN — St. Croix River, Dairyland, 24V67, 1 male (reared) (Nebeker and Bell); St. Croix River, Gordon, 30III67, 4 nymphs (Lemke and Mattson); Otter Creek, Sauk Co., 23IV72, 1 male (reared) (Flowers); Averill Creek, Lincoln Co., 25V72, 1 male (reared) (Flowers). PENNSYLVANIA — S. Branch Oswego Creek, Coneville, 24VII69, 1 male (Lewis). CANADA — Scott Creek, Riding Mt. Nat. Park, Manitoba, 20VI68, 1 nymph (Flannagan); Fairy Lake, Quebec, 30V27, 1 male (Holotype of *S. rivulicolum*) (Walley). Sandy Grey Falls, Go-Home River, Ontario, 23VI12, 1 male (Holotype) (Clemens); Renous River, Renous, New Brunswick, 18IX69, 1 nymph (Ulrich).

DISCUSSION

There has been some doubt as to whether *S. vicarium* and *S. fuscum* are valid species. Koss (1968) was not able to find any differences in the eggs of the two. Walton, University of Wisconsin (personal communication), collected a large number of nymphs of these two species from streams in Wisconsin. These nymphs could be arranged in a series starting with specimens that were typical of *S. vicarium* and progressing through intergradations to specimens typical of *S. fuscum*. I have seen this display and admit that it looks very convincing. Walton did not rear any nymphs, and I suspect that those he called *S. vicarium* were in reality *S. rivulicolum*, which I would expect to hybridize with *S. fuscum*. There is little doubt that *S. rivulicolum* (Fig. 132) is intermediate between *S. fuscum* and *S. vicarium*, as Traver (1933) noted. Burks (1953) synonymized *S. rivulicolum* with *S. vicarium* probably as a result of the reversed figures of the genitalia as mentioned above. The genitalia of the holotype of *S. rivulicolum* is definitely similar to the holotype of *S. fuscum*, and therefore, *S. rivulicolum* becomes a synonym of *S. fuscum*.

Although the nymphs of *S. vicarium* and *S. fuscum* can be separated only on the amount of dark coloration on the ninth sternum, there are good morphological characters for separating the adults based on wing veination and arrangement of spines on the genitalia.

Stenonema gildersleevei Traver

(Figures 8, 9, 16, 59, 81, 168)

Stenonema gildersleevei Traver, 1935: 315; Spieth, 1947: 103; Burks, 1953: 163

NYMPH: Length 9-11 mm.

Head: Mostly brown, areas lateral to compound eyes pale, pale areas near posterior margin; *maxilla* with 11-13 heavy pectinate spines on crown but without crown setae, 30-40 lateral setae (Fig. 59); *mandibles* each with 7-9 teeth on inner margin of outer canine, 3-7 teeth on inner margin of inner canine (Fig. 81).

Thorax: Mostly pale brown with a pair of large black spots on pronotum and several smaller black spots near wing bases; *legs* brown dorsally with scattered pale areas, ventral surfaces white; claws not pectinate.

Abdomen: Color pattern consists of elongate pale spots on dark brown background (Fig. 16); *terga* with black crossbands at posterior margins thus separating each elongate pale spot so that they do not form the pale submedian bands so characteristic of most nymphs of the *INTERPUNCTATUM* group; *sterna* white, faint longitudinal dashes at lateral margins of segments 7-9 often present; *gills* 1-6 pointed at apices (Fig. 8), fingerlike 7th gill with a single trachea but without a fringe of hairs (Fig. 9); *posterolateral angles* of segments 7-9 extended as spines; *caudal filaments* yellow throughout.

MALE IMAGO: See either Traver (1935), Spieth (1947), or Burks (1953) for a complete description.

Genitalia lacking apical spines but a terminal spine is present on each penis lobe (Fig. 168).

ECOLOGY AND DISTRIBUTION

This species seems to prefer cold, spring-fed streams. The type series examined was reared from nymphs taken from a spring-fed stream in northern Ohio. Four female imagos from near Hitchcock Creek, Pennsylvania, and a nymph from Laurel Brook, Tennessee, probably were inhabitants of extremely cold spring-fed streams (Fig. 195).

Specimens Examined: OHIO — Chagrin River Tributary, Kirtland, 22VIII30, 1 male (reared) (Paratype), 3 nymphs (Traver); same location, 31VIII29, 1 nymph (Traver); same location, 7IX32, 1 female (reared) (Paratype) (Traver); same location, 25VIII30, 1 female (reared) (Paratype) (Traver); same location, 6VIII32, 1 female (reared) (Paratype) (Traver); same location, 22IX32, 1 nymph (Traver); same location, 14IX30, 1 nymph (Traver); same location, 10VIII32, 1 nymph, 1 female (Paratype) (Traver). PENNSYLVANIA — Hitchcock Creek, Cherry Grove, 22VIII69, 4 females (Lewis). TENNESSEE—Laurel Brook, Walden Ridge, Rhea Co., 23IX69, 1 nymph (Lewis).

DISCUSSION

Adults of this species are often confused with *S. interpunctatum canadense* differing only in their larger size and in having a black longitudinal line on each sternum. Nymphs are separated from other closely related species, except *S. pallidum*, by the number of spines on the crown of the maxillae (11-13) and from *S. pallidum* by the number of lateral setae (30-45) and dorsal color pattern (Fig. 16).

Stenonema integrum (McDunnough)

(Figures 25, 37, 70, 97, 134, 139, 140, 160, 177)

Heptagenia integer McDunnough, 1924: 9
Stenonema integrum Traver, 1935: 317; Burks, 1953: 176
Stenonema metriotes Burks, 1953: 174 NEW SYNONYMY

NYMPH (Fig. 25): Length 7-8 mm.

Head: Dark brown, sprinkled with pale dots, a small medium spot and 2 larger lateral spots on anterior margin, lateral margins pale with brown band connecting each eye with lateral margin; pale areas near each ocellus; *maxilla* with 2 or 3 pectinate spines and 30-50 setae on crown; 15-25 lateral setae (Fig. 70); *mandibles* with 5-8 teeth on inner margin of outer canine (Fig. 97).

Thorax: Brown, a cuneiform-shaped pale streak begins near posterior margin of head, widens across pronotum, and tapers off near middle of mesonotum; *legs* mostly pale, each femur with 3 irregular transverse brown bands, tibiae with brown bands basally and near middle, basal half of tarsi brown, claws usually not pectinate.

Abdomen: Dark brown; *terga* 2-7 with pale submedian streaks on anterior portions, middle of tergum 1 mostly pale; a conspicuous pale "V-shaped" median patch with vertex on tergum 9 or 10 extends across terga 7 and 8; terga 4 and 5 often with pale submedian patches; pale lateral streak on terga 2-8 usually concealed under gills; *sterna* usually entirely pale except for sternum 9, which often has lateral dark bands that may coalesce anteriorly to form a dark inverted U-shaped mark (Fig. 37); *gills* 1-6 truncate at apices, fingerlike 7th gill with a fringe of hairs but no tracheae; *posterolateral angles* of segments 7-9 produced as spines; *caudal filaments* pale basally, ringed with brown beyond the middle with an alternating pattern of 3 brown segments separated by 1 pale segment.

MALE IMAGO (Fig. 139): Length 5-7 mm.

Head: Chalky white, vertex stained with pale yellow.

Thorax: Pronotum pale yellow; mesonotum and metanotum chalky white; pleura and vertex of thorax chalky white; *mesoscutellum* all white; *legs* yellowish white, each femur with prominant red-brown crossband near middle and at apex, fore tarsal ratio 1.5-2.0; *fore wing* hyaline, stigmatic area stained with brown, cross veins slightly crowed in bulla region, the cross veins in bulla region and beyond forming irregular lines across wing setting off elongate cells distal to bulla region (Fig. 160); *hind wing* usually with narrow brown apical margin.

Abdomen: White; *terga* 1-9 each with a narrow black cross band at posterior margin, those on terga 2-6 often reduced to a minute black median dash (Fig. 134), the narrow band on terga 7-9 often interrupted on the meson; a longitudinal dark gray line on meson of terga 3 and 6 (Fig. 140); spiracular marks, if present, a series of oblique dark brown streaks (Fig. 139); *genitalia* with discal spines on penis lobes (Fig. 177); *caudal filaments* white, joinings narrowly dark brown.

ECOLOGY AND DISTRIBUTION

S. integrum is distributed throughout most of the United States (Fig. 194). The nymphs are tolerant to a wide range of conditions and have been found in the Ohio River where pollution (both organic and toxic) had eliminated all the more intolerant mayfly species. Any permanent stream may harbor a few individuals, but the nymphs of this species seem to prefer large, deep rivers such as the Ohio and Mississippi, where they are especially abundant below sewage outfalls.

Specimens Examined: ARKANSAS — Arkansas River, Little Rock, 6VI68, 1 nymph (Woomer); Cove Creek, Washington Co., 6VI62, 1 male (Peters). FLORIDA — Blackwater River, Okaloosa Co., 1VI70, 5 males (Peters). ILLINOIS — Mississippi River, Poplar Bluff, 20VI43, 1 male (Frison); Alton, 27VIII13, 2 males (Paratypes) (McDunnough); Ohio River, Cairo, 22IX67, 1 nymph (Anderson). INDIANA — Great Miami River, Lawrenceburg, 23VII68, 1 nymph (Lewis); Ohio River, Madison, 14VII69, 3 nymphs (Lewis); Ohio River, Evansville, 5IX67, 1 nymph (Anderson); Wabash River, New Harmony, 15V63, 1 nymph (Anderson); same location, 15VII66, 1 nymph (Anderson); White River, Newberry, 14X65, 1 nymph (Anderson). KANSAS — Kansas River, Lawrence, 24IX59, 1 male (Peters). KENTUCKY — Ohio River, Louisville, 6VII66, 1 nymph (Mason); Ohio River, Warsaw, 17VI68, 1 nymph (Lewis). MAINE — Crooked River, Harrison, 14VII71, 1 female (Lewis). MINNESOTA — Mississippi River, Wabash, 7VII40, 1 female (reared), 1 male (Paratypes of *S. wabasha*) (Daggy); Mississippi River, Winona, 9VII37, 1 male (Paratype of *S. wabasha*) (Daggy); same location, 5VII37, 1 female (Daggy). NORTH CAROLINA — French Broad River, Penrose, 19VII30, 1 male (Holotype of *S. bellum*) (Traver). OHIO — Little Miami River, Loveland, 20X68, 1 female (reared); Little Miami River, Cincinnati, 8X68, 1 nymph (Lewis); Ohio River, Cincinnati, 2X68, 8 nymphs (Lewis); same location, 26VIII69, 1 male, 5 females (reared) (Lewis); same location, 5IX67, 3 nymphs (Lewis); same location, 22VIII70, 10 males (reared), 15 females (reared), 3 nymphs (Lewis); Ohio River, Portsmouth, 12IX68, 2 nymphs (Lewis); Ohio River, Miami Fort, 10IX68, 1 nymph (Lewis); Scioto River, Portsmouth, 11IX68, 1 nymph (Lewis). PENNSYLVANIA — Ohio River, Emsworth Dam, 16VI70, 1 nymph (Fullner). SOUTH CAROLINA — Clemson College, 26VI35, 1 female (Traver).

DISCUSSION

Much of the confusion that existed in this complex was cleared up by Burks (1953) when he synonymized *S. wa-*

basha Daggy and *S. bellum* Traver with *S. integrum*. The group is further simplified in this manual by synonymizing *S. metriotes* Burks with *S. integrum*.

When Burks (1953) first described *S. metriotes* he suggested that it "may eventually prove to be only a variant of *integrum*." I have examined the type series and must agree that they look distinct from *S. integrum*, and it leads me to wonder why Burks had reservations about the status of the species. However, during rearing of 41 nymphs of *S. integrum* from the Ohio River, imagos of *S. metriotes* consistently turned up in the tanks even though there was no visible difference in the nymphs. Eleven of the 16 *S. metriotes* were males and 19 of the 25 *S. integrum* were females. Apparently *S. metriotes* is a variant of *S. integrum*, usually a male, in which the black coloration is considerably reduced so that the spiracular dots are absent and the dark lines at the posterior margins of the abdominal terga are reduced to short, median dashes (Fig. 134). Several specimens showed intermediate characters.

Descriptions and photographs of both nymphs and adults of *S. integrum* appearing in this manual were taken from Ohio River specimens; however, reared males from the Ohio River nymphs were compared with McDunnough's holotype and found to be similar. The nymph originally described by Daggy (1945) as *S. wabasha* and later synonymized with *S. integrum* by Burks (1953) differs from these Ohio River nymphs in having only 5 or 6 teeth on the inner margin of the outer canine of each mandible and pectinate claws. Adults of *S. wabasha* lack the narrow dark apical margins on the hind wings, the fore wings lack elongate cells as characteristic of the Ohio River specimens, and there are slight differences in the genitalia. I consider the specimens from Minnesota and Wisconsin to be subspecies *S. integrum wabasha*.

Stenonema interpunctatum (Say)

(Figures 14, 35, 36, 56, 85, 86, 122, 123,
124, 125, 126, 149, 150, 169)

Baetis interpunctata Say, 1839: 14
Stenonema interpunctatum interpunctatum Spieth, 1947: 106
Stenonema interpunctatum canadense Spieth, 1947: 107
Stenonema interpunctatum frontale Spieth, 1947: 109
Stenonema interpunctatum heterotarsale Spieth, 1947: 110
Stenonema interpunctatum Traver, 1935: 317; Spieth, 1947: 104; Burks, 1953: 166
Stenonema areion Burks 1953: 163 NEW SYNONYMY

NYMPH: Length 8-11 mm.
Head: Anterior to compound eyes uniform brown; pale spots on margins lateral to compound eyes and near each ocellus, sometimes with light spots on anterior margin; *maxilla* with 8-10 heavy pectinate spines and no setae on crown, 20-30 lateral setae (Fig. 56); *mandibles* each with 5-7 teeth on inner margin of outer canine, inner canine with 2-4 blunt teeth on inner margin (Figs. 85 and 86).
Thorax: Mostly uniform brown, pronotum with a pair of sublateral and a pair of anterolateral pale spots; *legs* light brown dorsally, femora with pale spots forming 3 irregular bands across dorsal surface, pale ventrally, claws not pectinate.
Abdomen: Ground color brown; *terga* 1-9 with 1 or 2 pairs of nearly continuous longitudinal pale streaks length of abdomen (Fig. 14); *sterna* mostly white, often with dark shading in lateral areas (Figs. 35 and 36); *gills* 1-6 pointed at apices, 7th gill with tracheae but without fringe of hairs; *posterolateral angles* of segments 7-9 extended as spines; *caudal filaments* light brown usually with articulations alternating light and dark in apical third.

MALE IMAGO (Figs. 124 and 126): Length 8-10 mm.
Head: Yellow or white often tinged with green, black dot, dash, or line usually present on clypeus under antennal sockets (Fig. 125), vertex usually reddish brown.
Thorax: Pronotum white usually with oblique black streak on each side, remainder of thorax brown dorsally; *mesoscutellum* yellow with brown tip; *legs* yellow, each femur with dark brown crossbands at apex and near middle, hind femur often lacks median crossband, tibiae black at apices, fore tarsal ratio 1.1-3.5; *fore wing* hyaline, stigmatic area stained with brown, usually 2 or more cross veins in radial space in bulla region connected with black dash (Fig. 150); *hind wing* with brown apical margin (Fig. 149).
Abdomen: Yellow or white, sometimes with dark shading on meson (Fig. 123), apical 3 *terga* shaded with pink, orange, or brown, posterior margin of each tergum with narrow black crossband (Fig. 122), spiracular black marks present in some subspecies, absent in others; *genitalia* with apical spines either very small or apparently lacking (Fig. 169).

ECOLOGY AND DISTRIBUTION

Nymphs of *Stenonema interpunctatum* are common in almost any unpolluted stream east of the Rocky Mountains, and at least one subspecies is apparently able to tolerate considerable organic enrichment (Gaufin, 1958). I have collected the nymphs from a stream in southern Ohio that received moderate amounts of organic pollutants from an overloaded sewage treatment plant; however, the current was swift and the DO was near saturation. In the Ohio River downstream from Cincinnati where the DO often falls below 4.0 ppm during the summer, the nymphs of *S. interpunctatum* are generally scarce, whereas they are abundant in the unaffected reaches upstream of the city.

The presently recognized subspecies are distributed as follows (Fig. 196): *Stenonema interpunctatum canadense* (Walker) sensu Spieth is a dark, northern form of the species inhabiting lakes and pools of clean water streams of eastern Canada and the northern tier of the eastern and midwestern States, and extending southward along the eastern highlands to North Carolina. *Stenonema interpunctatum frontale* (Burks) sensu Spieth is an eastern subspecies inhabiting clean water streams from Lake Erie to the Atlantic Seaboard. *Stenonema interpunctatum interpunctatum* (Say) sensu Spieth is common and widespread in small streams and rivers in the lower and middle Mississippi and in the Ohio River drainages. Nymphs were common in rocky-bottomed streams where pH ranged from 6.7-8.2, the TDS ranged from 98-700 mg/l, the TDP ranged from 0.0-10.0 mg/l, and DO ranged from 4.0-14.0 mg/l. The form designated *S. affine* Traver is common in streams of the southeastern States. The distribution of *Stenonema interpunctatum heterotarsale* (McDunnough) sensu Spieth is centered around Lake Erie and Lake Ontario and extends westward into northern Indiana and Illinois and southward to central Ohio.

Specimens Examined: *Stenonema interpunctatum interpunctatum:* FLORIDA — Chipola River, Calhoun Co., 20IV72, 2 males (Carlson); same location, 12IV72, 1 male (Carlson). ILLINOIS — Fox River, St. Charles, 9VI48, 1 male (Burks); Muddy River, Benton, 10VI46, 1 male (Ross); Vermilion River, Oakwood, 6VI25, 1 nymph (Frison). INDIANA — Big Blue River, Shelbyville, 4VIII69, 1 nymph (Lewis); Wabash River, Wabash, 5VIII69, 1 nymph (Lewis); Wildcat Creek, Prymont, 4VIII69, 3 females, 1 nymph (Lewis); Wildcat Creek, Rossville, 4VIII69, 1 female, 1 nymph (Lewis); Wildcat Creek, Jerome, 5VIII69, 1 nymph (Lewis). KANSAS—Lawrence, 16VII32, 1 male (Brown). KENTUCKY — Kentucky River, Wilmore, 15VIII69, 1 nymph (Lewis); W. Fork Drakes Creek, Franklin, 1V71, 1 male (Myers). NORTH CAROLINA — Caraway Creek, Sophia 23IV30, 1 male (Holotype of *S. affine*) (Traver). OHIO — Chagrin River, Willoughby, 17VIII32, 1 male (Holotype of *S. conjunctum*) (Traver); Ohio River, Cincinnati, 22VIII70, 2 nymphs (Lewis); Shayler Run, Union Township, 23IV71, 3 males (reared), 1 female subimago, 1 nymph (Lewis); same location, 28V69, 2 males, 1 female, 2 nymphs (Mason); same location 13VI69, 2 nymphs, 2 females (Lewis); Stillwater River, Pikeville, 17IX69, 1 nymph (Lewis); White Lake, Waverly, 4VI69, 1 nymph (Lewis). OKLAHOMA — Blue River, Reagan, 1V39, 1 male (Ross). WEST VIRGINIA — Potomac River, Smoke Hole, 7VIII30, 1 nymph (Paratype of *S. affine*) Traver.

Stenonema interpunctatum canadense: ILLINOIS — Oakwood, 25VI48, 2 males (Paratypes of *S. areion*) (Burks). INDIANA — Wildcat Creek, Prymont, 4VIII69, 1 female, 1 nymph (Lewis). MAINE — Crooked River, Harrison, 17VII71, 2 females (reared) (Lewis). MICHIGAN — Davis Creek, Silver Lake, 18III71, 1 nymph (Meier). NEW YORK — Susquehanna River, Binghamton, 18VIII68, 1 nymph (Lewis). PENNSYLVANIA — Hitchcock Creek, Cherry Grove, 22VII69, 3 females (Lewis); S. Fork Oswego Creek, Coneville, 24VII69, 1 female, 1 nymph (Lewis). OHIO — Paine Creek, Leroy, 7VIII33, 2 males, 2 females (Paratypes of *S. ohioense*) (Traver); Chagrin River, Pleasant Valley, 25VIII30, 1 female (reared) (Traver); same location, 31VIII29, 1 male (subimago) (Traver); same location, 14IX30, 1 nymph (Traver). CANADA — Willow Creek, 40 mi. w. of Winnipeg, Manitoba, 7VIII68, 2 males (reared) (Flannagan); Britannia, Ontario, 14VI22, 1 male, 1 female (McDunnough).

Stenonema interpunctatum frontale: MAINE — Carsley Brook, Harrison, 12VII71, 1 male (reared), 1 nymph (Lewis). MASSACHUSETTS — Middlesex Falls, no date, 1 male (Holotype) (Banks). NEW YORK — Cranberry Lake, 26VI20, 1 female (Drake); Cascidilla Creek, Ithaca, 16VII32, 1 male (Holotype of *S. majus*) (Traver); White Church (Ithaca) 12VI33, 2 males, 1 female (Holotype and Paratypes of *S. proximum*) (Traver); Wilseyville Creek, Ithaca, 10VI33, 2 males (Paratypes of *S. proximum*) (Greenwald). CANADA — Little S.W. Miramichi River, New Brunswick, 14IX69, 1 nymph (Ulrich); Ottawa Golf Club, Quebec, 21VII24, 1 male (Homotype) (Ide).

Stenonema interpunctatum heterotarsale: ILLINOIS — Little Wabash River, Crossville, 6VIII69, 1 male, 1 female (subimagos) (Lewis); Vermilion River, Oakwood, 6VI25, 1 nymph (Frison). OHIO — Little Miami River, Cincinnati, 18VII68, 1 male (Lewis); Mohican River, Danville, 23VI69, 2 females (reared), 1 nymph (Lewis); CANADA — Ottawa, Ontario, 19VI24, 1 male (Paratype) (Ide); same location, 13VI27, 1 male (McDunnough).

DISCUSSION

Both nymphs and imagos are very similar to *S. minnetonka*, *S. floridense*, and *S. pallidum*, differing primarily in the arrangement of spines on the male genitalia and the number of spines on the crown of the maxillae of the nymphs. See the discussion under those species for descriptions of characters used to separate the four species and Spieth (1947) for descriptions of the four subspecies.

The *S. interpunctatum* complex is, at present, only superficially known; therefore, the foregoing diagnosis must be considered tentative until confirmed by careful rearing of nymphs from many localities to help us understand the distribution patterns of the several subspecies (or species). All the different populations must be segregated out and areas of hybridization pinpointed. Studies should be designed to ascertain whether the apparent hybrids are truly hybrids or are environmental variants within species. The influence of glaciation and biogeography on the distribution of the several populations needs investigation. Are the apparent subspecies the result of glacial segregation? If so, are they now intermingling over their entire ranges?

Spieth (1947) recognized 4 subspecies of *S. interpunctatum (heterotarsale, interpunctatum, frontale*, and *canadense)*, based on first fore tarsal ratio and fore wing length of the males, and synonymized 6 other species under *S. interpunctatum* (see Table 2). The nymph of subspecies *S. heterotarsale* has not as yet been positively associated with the adult by rearing, and the differences between the nymphs of subspecies *canadense*, *frontale*, and *interpunctatum* are so minor that it is not wise at this time to attempt to separate them without the associated imagos.

Although the imagos of these subspecies have definite color patterns, they cannot be recognized as distinct species because of obvious hybridization and similarities in genitalia. *S. interpunctatum frontale* hybridizes with *S. interpunctatum canadense* in central and western New York, southern Ontario, northern Ohio, and western Pennsylvania, and with *S. interpunctatum interpunctatum* in southern New York, Ohio, and Kentucky. Hybrids resulting from crosses between *S. interpunctatum heterotarsale* and *S. interpunctatum canadense* were examined from eastern Illinois, southern Ontario, and southern Michigan. *S. interpunctatum heterotarsale* hybridizes with *S. interpunctatum* s.s. in north-central Indiana. Hybrids of *S. interpunctatum interpunctatum* and *S. interpunctatum canadense* appear to be common in all the midwestern States north of the Ohio River.

The type specimens of *S. areion* Burks (Fig. 122) from Illinois appear to be hybrids between *S. interpunctatum heterotarsale* and *S. interpunctatum canadense*. The lack of dark spiracular dots and dark facial marks may be attributable to *S. heterotarsale*, but the genitalia are distinctly similar to that of *S. interpunctatum canadense*. Posterior margins of the terga of the holotype and paratypes have dark brown bands, rather than a "mars orange crossband" as stated by Burks (1953). It is possible that the color changed upon drying, but other specimens from near the "type locality" had the characteristic dark brown crossband. The fore tarsal ratio for 5 specimens of *S. areion* ranged from 2.1-2.6, which is well within the range for *S. interpunctatum canadense*. Two of these specimens had dark pleural streaks, and one had the dark spiracular dots characteristic of *S. interpunctatum canadense*. None of these Illinois specimens possessed the dark median longitudinal band on the terga (Fig. 123) so characteristic of *S. interpunctatum canadense* from Canada. The genitalia of all five specimens were similar to those of *S. canadense* from Ontario and Illinois. For these reasons *S. areion* is reduced to a junior synonymy of *S. interpunctatum canadense*, accepting in principle Spieth's (1947) diagnosis of the group. See Table 2 for subspecies and synonyms.

Stenonema ithaca (Clemens and Leonard)

(Figures 27, 41, 67, 93, 131, 161, 182)

Heptagenia ithaca Clemens and Leonard, 1924: 17
Stenonema ithaca Traver, 1935: 318; Burks, 1953: 173

NYMPH: Length 10-11 mm.

Head: Light brown speckled with small pale dots, a pale oblique band extending from anterolateral angle of each compound eye to lateral margins; *maxilla* with 4-6 pectinate spines but without setae on crown, 15-25 lateral setae (Fig.

67); *mandibles* each with 6-7 teeth on inner margin of outer canine (Fig. 93).

Thorax: Mostly brown; *legs* pale with 2 broad light brown bands across each femur, claws not pectinate.

Abdomen: Light brown ground color; *terga* with a few pale blotches and small dots (Fig. 27); *sterna* 4-8 white with brown angulated transverse bars across middle (Fig. 41), sternum 9 with pair of oblique brown bands sometimes meeting on meson at anterior margin to form an inverted "V"; *gills* 1-6 truncate at apices, 7th gill with fringe of hairs but without tracheae; *posterolateral angles* of segments 7-9 extended as spines; *caudal filaments* uniformly yellow, sometimes with alternating dark and light segments near tip.

MALE IMAGO: Length 9-10 mm.

Head: Dark red-brown, face below antennal sockets usually with a narrow black line across face, antennae brown at base becoming hyaline near tips.

Thorax: Dark red-brown on nota, pleura mostly yellow-brown with darker shading at wing bases; *mesoscutellum* dark red-brown; *legs* yellow with reddish shading except fore femora, which are light reddish-brown, each femur with a median and apical purple band, fore tarsal ratio 2.0-2.3; *fore wing* hyaline with numerous cross veins forming short cells, cross veins in bulla region slightly crowded, usually 1 cross vein in costal space and 2 or 3 in each of the 2 following spaces (Fig. 161), stigmatic area washed with yellow-brown; *hind wing* hyaline without dark apical margin.

Abdomen: Mostly dark brown; *terga* 1-7 slightly lighter at anterior margins, stigmal dots obscured by dark brown shading (Fig. 131); *genitalia* with minute apical spine and small subterminal spine on each penis lobe (Fig. 182); *caudal filaments* yellow with dark joints.

ECOLOGY AND DISTRIBUTION

Nymphs of *S. ithaca* prefer the gentle riffles of small rivers and large streams to the fast water of smaller streams. This species appears to be restricted to the Finger Lake Region and the Susquehanna watershed of central New York (Fig. 189) although it has often been reported elsewhere because of misidentification (Burks 1953). Possibly additional collecting and study of museum specimens may result in extending the distribution.

Specimens Examined: NEW YORK — Beaver Creek, Chicago, 20VI32, 1 male, 1 female (reared) (Traver); Fish Hatchery, Ithaca, 5IV31, 2 males, 2 females (reared); same location, 16VI31, 1 male, 1 female (Sadler); Ithaca, 1VI85, 1 male; Cass Creek, Ithaca, 21VI13, 1 male (Holotype) (Clemens); same location, 7VI14, 1 male, 1 female (Paratypes) (Clemens).

DISCUSSION

The use of characters given in the keys of this manual will, for the first time, separate both the adults and nymphs from the dark form of *S. rubromaculatum* with which this species has previously been confused.

Stenonema lepton Burks

Stenonema lepton Burks, 1946: 614; Burks, 1953: 176

NYMPH: Unknown.

MALE IMAGO: Burks (1953) has adequately described the male of this species.
Genitalia with no discal or terminal spines on the penis lobes.

ECOLOGY AND DISTRIBUTION

Nothing is known of the ecology of this species. The type series was collected near an unpolluted reach of the Kankakee River and it seems to be endemic to that river system (Fig. 191).

Specimens Examined: ILLINOIS — Kankakee River, Momence, 24VI39, 1 male (Paratype) (Burks and Ayars).

DISCUSSION

There is some doubt as to the status of *S. lepton*. The nymph of *S. lepton* is not known, and the adult is close to *S. terminatum*. Adults differ from *S. terminatum* in having a fore tarsal ratio of 1.2-1.5 rather than 2.0-2.3, the range of *S. terminatum*. The penis lobes of *S. lepton* have only 1 spine each (the inner apical) whereas *S. terminatum* has 2 spines.

Stenonema luteum (Clemens)

(Figures 20, 34, 45, 77, 98, 111, 142, 144, 188)

Heptagenia lutea Clemens, 1913: 252; 1915: 135
Ecdyonurus luteus McDunnough, 1933: 34
Stenonema luteum Traver, 1935: 319; Burks, 1953: 175

NYMPH: Length 10 mm.

Head: Light brown sprinkled with white dots, white spots surrounding ocelli and on meson at posterior margin, large white area lateral to each compound eye; *maxilla* with 2-4 pectinate spines and 30-40 setae on crown, 18-25 lateral setae (Fig. 77); *mandibles* each with 6 or 7 teeth on inner margin of outer canine (Fig. 98).

Thorax: Light brown with numerous irregular light spots, lateral border of pronotum hyaline; *legs* fringed with long hairs along posterior margins, femora with alternately light and dark irregular bands and covered with minute spines dorsally, venter of femora white, tibiae with basal and median brown bands, tarsi with basal brown band, claws pectinate (Fig. 111).

Abdomen: Dark brown with varying amounts of white coloration; *terga* 1-3 mostly white, remaining segments with complicated pattern of brown and white (see Figs. 20 and 34); *sterna* 2-8 pale with dark lateral and posterior margins (Fig. 45), segments 8 and 9 with two large brown spots often connected at posterior margins; *gills* 1-6 truncate at apices, 7th gill fringed with long hairs but lacking tracheae; *posterolateral angles* of segments 3-9 extended as spines; *caudal filaments* greenish-white basally, beyond middle each two segments alternately dark and white.

MALE IMAGO (Fig. 144): See either Burks (1953) or Traver (1935) for a complete description.
Genitalia with large terminal and apical spines on penis lobes (Fig. 188).

ECOLOGY AND DISTRIBUTION

This is a northern species that inhabits lake shores and rapids of rivers of southern Canada and the northern states west of the Great Lakes (Fig. 193). It is apparently a clean water form.

Specimens Examined: ILLINOIS — Mississippi River, Savanna, 29VI35, 1 male (Delong and Ross). WISCONSIN — Fourteen Mile Creek, Friendship, 31X68, 1 nymph (Hilsenhoff); W. Branch Pecatonica River, Lafayette Co., 27IV72, 1 male (Flowers). CANADA — Go-Home-Bay, Ontario, 29VII12, 1 male (Holotype) (Clemens) (this specimen was designated as Holotype by McDunnough in 1933); same location, 21VII24, 1 male (Ide); same location, 30VI32, 1 male (reared) (Walley); Ottawa, Ontario, 4VI22, 1 male (Homotype) (Clemens).

DISCUSSION

Nymphs of this species are quite variable in the amount of dark shading on the terga and along the posterior margins of the sterna. Nymphs from Wisconsin identified as *S. luteum* by Ide may represent an undescribed species. The characteristic dark band along the posterior margins of each sternum is missing from these Wisconsin nymphs. A male imago reared from one of these nymphs has oblique grey spiracular dashes (Fig. 142), whereas the types have no spiracular markings. Most specimens from both populations can be identified by characters used in the key.

Stenonema mediopunctatum (McDunnough)

(Figures 22, 44, 78, 102, 141)

Ecdyonurus mediopunctatus McDunnough, 1926: 191
Stenonema mediopunctatum Traver, 1935: 321; Burks, 1953: 174

NYMPH: Length 7-9 mm.

Head: Brown speckled with pale dots, 2 pale spots lateral to each compound eye separated by a narrow brown band; *maxilla* with 4-6 pectinate spines and 1-5 setae on the crown, 25-40 lateral setae (Fig. 78); *mandibles* each with 7-8 teeth on inner margin of outer canine (Fig. 102).
Thorax: Brown with small pale dots; *legs* white with irregular brown spots forming bands across femora, brown bands on tibiae at base and middle, claws not pectinate.
Abdomen: With *terga* 1-4, 6, 8-10 predominately brown, terga 5 and 7 mostly white (Fig. 22); *sterna* 4-8 (often 2 and 3 also) pale with a curved brown cross bar near each anterior margin (sometimes entire anterior half of each sternum is dark brown), sternum 9 with U-shaped brown mark with open end directed posteriorly (anterior end of U not always completely closed) (Fig. 44); *gills* 1-6 truncate at apices, 7th gill with fringe of hairs but without tracheae; *posterolateral angles* of segments 3 (or 5)-9 extended as spines; *caudal filaments* pale with articulations darker.

MALE IMAGO (Fig. 141): Length 9 mm.

Head: Whitish anterior to compound eyes, becoming light brown on vertex.
Thorax: Deep black-brown; *mesoscutellum* black-brown with light brown tip; *legs* white with median and apical purplish bands on femora, fore tarsal ratio 1.5-1.8; *fore wing* hyaline with 1 or 2 cross veins in each of the first 3 interspaces; *hind wing* without dark band at apex.
Abdomen: White; *terga* 2-7 each with a small transverse black dash on meson at posterior margin, black spiracular dots on segments 4-7, segments 8-10 opaque white shaded with brown; *genitalia* with small terminal spines and minute apical spines on penis lobes; *caudal filaments* entirely white.

ECOLOGY AND DISTRIBUTION

The reported distribution of this species is limited to the area just north and west of the Great Lakes (Fig. 195). Nymphs have been collected only from clean water streams.

Specimens Examined: NEW YORK — Niagara River, Buffalo, no date, 1 female. WISCONSIN — Apple River, Little Falls, 19VI68, 1 nymph (Hilsenhoff); Moose Ear Creek, Barron, 21V69, 1 nymph (Hilsenhoff); Turtle Creek, Turtle Lake, 27V69, 1 nymph (Hilsenhoff). CANADA — Stream 40 mi SE of Kenora, Ontario, 28VI68, 1 male (Flannagan); Walsh, Ontario, no date, 1 male (Holotype) (Walley); Victoria Harbor, Ontario, no date, 1 male (Paratype).

DISCUSSION

A description of the nymph of this species has not been published, and its inclusion in the key is based on several nymphs from Wisconsin identified by Ide, who said that he can separate the nymphs of this species from the closely related *S. nepotellum* (personal communication). Adult characters used in the key are based on the holotype and a paratype. Something of the problem involving the relationship between *S. mediopunctatum* and *S. nepotellum* can be gathered from the fact that Daggy (1941) reported *S. nepotellum* common in Minnesota but did not collect any *S. mediopunctatum*, whereas Krueger (1969) reported *S. mediopunctatum* common in Wisconsin but reported no *S. nepotellum*. The specimens reported by both these workers appear to be similar to those identified by Ide as *S. mediopunctatum*, and I will accept his identifications until they are shown to be in error. It is possible that *S. nepotellum* is a southern form of *S. mediopunctatum* as discussed under that species. Rearing and comparative studies will be needed to resolve this problem.

Stenonema minnetonka Daggy

(Figures 60, 80)

Stenonema minnetonka Daggy, 1945: 376; Burks, 1953: 164

NYMPH: Length 8-10 mm.

Head: Anterior to compound eyes uniform brown with a pale spot usually present on anterior margin at meson, 2 large pale spots lateral to each eye separated by brown band; *maxilla* with 9-10 pectinate spines on crown, 30-40 lateral setae (Fig. 60); *mandibles* each with 6-7 teeth on inner margin of outer canine; inner margin of inner canine with 3-4 blunt teeth (Fig. 80).
Thorax: Brown with a few pale areas on pronotum; *legs* brown, each femur with a basal, median, and apical white cross band, each tibia white near base and at apex, claws not pectinate.
Abdomen: Brown; *terga* 1-10 each with a pair of submedian longitudinal pale streaks forming continuous stripes, those on terga 8 and 9 widest and those on tergum 10 much reduced; *sterna* 4-8 with lateral margins brown, posterior fourth of tergum 9 brown; *gills* 1-6 pointed at apices, 7th gill with tracheae but without a fringe of hairs; *posterolateral angles* of segments 7-9 extended as spines; *caudal filaments* light brown in basal half, alternating dark and light segments apically.

MALE IMAGO: See Burks (1953) for complete description.
Genitalia are distinctive in that the apical spine on each penis lobe is larger than the terminal spine, just the reverse of the related species (See Burks, 1953, his figure 335).

ECOLOGY AND DISTRIBUTION

Nymphs that are believed to be this species were collected and reared from a small creek in southwest Ohio, but the type series and other adults reported as this species were taken near large rivers in Minnesota and Illinois (Fig. 195).

Specimens Examined: ILLINOIS — Rockford, 22V41, 1 male (Ross and Burks). KENTUCKY — Beargrass Creek, Louisville, 3VI38, 1 male (Burks). OHIO — Kain Run, Williamsburg, 27V71, 2 females (reared) (Lewis); Little Miami River, Loveland, 10X68, 1 female (Lewis).

DISCUSSION

This species has previously been known only from a few adults collected along the Mississippi and Rock Rivers in southern Minnesota and northern Illinois. The nymphal description given above was based on the exuvia of a reared female from Kain Run, Ohio: therefore, this description must be considered tentative until substantiated by positive association with a reared male. As yet I have not been able to examine the type series to determine its relationship to the *S. interpunctatum* complex from which it differs primarily in the arrangement of spines on the genitalia. In *S. interpunctatum*, the apical spine is either completely missing or, if present, much smaller than the terminal spine (Fig. 169). In contrast, the apical spine of *S. minnetonka* is at least as large as the terminal spine. Additional collection and rearing will be needed to fix the status of *S. minnetonka* with certainty.

Stenonema modestum (Banks)

(Figure 174)

Epeorus modestus Banks, 1910: 202
Iron modestus McDunnough, 1924: 129; Traver, 1935: 406
Stenonema modestum Burks, 1953: 155

NYMPH: Unknown.

MALE IMAGO: Length 6-7 mm.

Head: White.

Thorax: Dark brown; *mesoscutellum* brown; *legs* pale, each femur with median and apical brown bands, apex of each tibia black, fore tarsal ratio 1.1-1.3; *fore wing* hyaline with cross veins not crowded in bulla region; *hind wing* not dark banded at apex.

Abdomen: Pale; *terga* with dark spiracular dots and narrow black lines at posterior margins, terga 9-10 dark reddish-brown; *genitalia* with a minute apical and small discal spine on each penis lobe (Fig. 174); *caudal filaments* pale, alternating joints dark.

ECOLOGY AND DISTRIBUTION

The holotype was taken in the vicinity of the Potomac River where the nymphs probably developed (Fig. 192).

Specimens Examined: DISTRICT OF COLUMBIA — Washington, no date, 1 male (Holotype) (Banks).

DISCUSSION

This species is so similar to *S. rubrum* in appearance that specimens cannot be distinguished except by fore tarsal ratio and arrangement of spines on the genitalia. The fore tarsal ratio of *S. modestum* is 1.1-1.3 compared with 1.7 for *S. rubrum*. Compare figures 174 and 185 for differences in the genitalia.

Stenonema modestum has not been reported since the types were collected in 1910; however, *S. rubrum* nymphs have been reported regularly from the Potomac River. Rearing of *S. rubrum* nymphs from the Potomac River might clear up the uncertain status of *S. modestum*.

Stenonema nepotellum (McDunnough)

(Figures 42, 68, 108, 145, 162, 186)

Ecdyonurus nepotellus McDunnough, 1933: 20
Stenonema nepotellum Traver, 1935: 322; Burks, 1953: 177

NYMPH: Length 7-9 mm.

Head: Brown with large pale spots lateral to compound eyes; *maxilla* with 4-6 pectinate spines but without setae on crown, 25-30 lateral setae (Fig. 68); *mandibles* each with 8 teeth on inner margin of outer canine (Fig. 108).

Thorax: Brown, pronotum with large pale area at each lateral margin; *legs* brown dorsally with 3 irregular white bands on each femur, claws pectinate.

Abdomen: Brown with a few vague pale areas; *terga* 5 and 7 predominantly pale, others mostly dark brown; *sterna* 2-8 white with dark brown cross bar near each anterior margin (sometimes anterior half of sterna dark), sternum 9 with U-shaped brown mark, open posteriorly (Fig. 42); *gills* 1-6 truncate at apices, 7th gill with fringe of hairs but lacking tracheae; *posterolateral angles* 5-9 extended as spines; *caudal filaments* light brown basally, alternating pairs of light and dark segments apically.

MALE IMAGO (Fig. 145): See Burks (1953) for complete description.

Fore wing with cross veins slightly crowded at bulla (Fig. 162); *genitalia* with minute apical spine and large terminal spine on penis lobes (Fig. 186).

ECOLOGY AND DISTRIBUTION

The distribution (Fig. 197) of this species is in doubt because of the confusion in the taxonomy of the species. Most records from the midwestern and southeastern states are probably reliable, but the Minnesota records and some of the Canadian records of *S. nepotellum* must be questioned because of its confusion with *S. mediopunctatum*. The nymphs seem to prefer medium sized streams with a moderate current flowing over bedrock. They are able to tolerate moderate amounts of organic enrichment.

Specimens Examined: ILLINOIS — Nippersink Creek, Spring Grove, 21VI38, 1 male, 1 nymph (Ross and Burks). INDIANA — Sugar Creek, London, 4VIII69, 4 females (reared), 5 nymphs (Lewis). KENTUCKY — W. Fork Drakes Creek, Franklin, 21V71, 7 males (reared), 4 females (reared) (Myers); same location, 3V71, 1 male (Myers); same location, 18V71, 1 male (Myers); same location, 20V71, 1 male (Myers). MISSOURI — Shoal Creek, Joplin, 7VIII57, 1 nymph (Peters). TENNESSEE —Duck River, Powers Bridge, 8VIII72, 1 nymph (Sinclair). CANADA — Fulford, Quebec, 15VIII30, 1 male (Holotype) (Milne); same location, no date, 1 male (Paratype) (Milne).

DISCUSSION

Adults of *S. nepotellum* are quite similar to *S. annexum* and *S. rubrum* but differences in the arrangement of spines on the penis lobes are diagnostic. A series of 38 male imagos collected by Frank Myers from Simpson County, Kentucky, contained both *S. nepotellum* and *S. annexum*. Although differences in the genitalia remained constant, there was considerable variation in both size and color. Nymphs from the same creek show equal amounts of variability, but there was no concrete evidence of interbreeding.

There is the possibility that *S. nepotellum* is a southern form of *S. mediopunctatum*, as discussed under that species. The nymphs are very similar and differ only in the number of setae on the crown of the maxilla and amount of ventral maculation. The adults differ slightly in color intensity and in details of the arrangement of spines on the penis lobes.

Stenonema pallidum Traver

(Figures 57, 83, 120, 165)

Stenonema pallidum Traver, 1933: 181; Traver, 1935: 323
Stenonema interpunctatum interpunctatum Spieth, 1947: 106 (unjustified synonymy)

NYMPH: Length 6-8 mm.

Head: Reddish brown, pale spot anterior to median ocellus and lateral to each lateral ocellus; *maxilla* with 11-13 pectinate spines on crown, approximately 25 lateral setae (Fig. 57); *mandibles* each with 5-8 teeth on inner margin of outer canine, 2 blunt teeth on inner margin of inner canine (Fig. 83).

Thorax: Reddish brown with pale areas near lateral and anterior margins of pronotum; *legs* white, each femur with 3 irregular brown bands, claws not pectinate.
Abdomen: Reddish brown with submedian pale streaks consisting of a series of elongate spots such as in *S. gildersleevei*, but in this species, the spots are connected to form continuous lines; *terga* with black bands at posterior margins; *sterna* 4-8 dark at lateral margins, sternum 9 dark at posterior and lateral margins; *gills* 1-6 pointed at apices, 7th gill with tracheae but without fringe of hairs; *posterolateral angles* of segments 7-9 extended as spines; *caudal filaments* pale tan.

MALE IMAGO (Fig. 120): See Traver (1935) for complete description.
Genitalia are illustrated in Fig. 165.

ECOLOGY AND DISTRIBUTION

This species has been collected only in the mountains of North Carolina (Fig. 193). Nymphs inhabit swift mountain streams and appear to be intolerant of pollution.

Specimens Examined: NORTH CAROLINA — The Cascades, Danbury, 21V29, 1 male (Paratype) (reared) (Traver); Watauga River, Valle Crucis, 7VI36, 1 nymph (Traver).

DISCUSSION

This species is superficially similar to *S. interpunctatum*, which apparently prompted Spieth (1947) to synonymize it with that species. Examination of the holotype and its nymphal exuvia reveals that Spieth's synonymization of this species with *S. interpunctatum interpunctatum* was unjustified. In the adult, the arrangement and shape of the spines on the penis lobes of the genitalia differ noticeably from *S. interpunctatum interpunctatum* (compare Figs. 169 and 165). Nymphs differ in having 11-13 pectinate setae on the crown of the maxillae compared with 9 or 10 for *S. interpunctatum* nymphs. Additional rearing may ultimately result in proving this species to be synonymous with *S. interpunctatum* or *S. gildersleevei*, but until such proof is available *S. pallidum* should be considered a distinct species.

Stenonema placitum (Banks)

(Figure 180)

Heptagenia placita Banks, 1910: 199
Stenonema placitum Traver, 1935: 324; Burks 1953: 175

NYMPH: Unknown.

MALE IMAGO: See Traver (1935) for complete description.
Genitalia with small to minute apical spines and very large subterminal spines on penis lobes (Fig. 180).

ECOLOGY AND DISTRIBUTION

Adults of this species have been reported from northern New York and southern Quebec Province (Fig. 192) in areas where little pollution exists.

Specimens Examined: NEW YORK—Sport Island, Sacandaga River, no date, 1 male (Holotype) (Alexander). CANADA—Vaudreuil, Quebec, 23VI30, 1 male (Walley).

DISCUSSION

Burks' (1953) synonymization of *S. placitum* with *S. terminatum* seems unjustified because of the unique character of the male genitalia and differences in the fore tarsal ratio. The subterminal spine of each penis lobe of *S. placitum* is large and wide at the base whereas that of *S. terminatum* is small and narrow. The fore tarsal ratio of males of *S. placitum* is 1.8, whereas *S. terminatum* has a fore tarsal ratio of 2.2. Discovery of the nymph and rearing of *S. terminatum* and *S. placitum* should yield answers to the questions concerning the relationship between these 2 species.

Stenonema pudicum (Hagen)

(Figures 26, 43, 71, 99, 118, 136, 137, 158, 181)

Ephemera pudica Hagen, 1861: 39
Ecdyonurus pudicus McDunnough, 1925: 191 (not synonym of *S. vicarium*)
Stenonema pudicum Traver, 1935: 326; Burks, 1953: 171

NYMPH: Length 12-14 mm.
Head: Dark brown, freckled with pale dots, area lateral to compound eyes pale; *maxilla* with 5-8 pectinate spines and 20-40 setae on crown, 20-40 lateral setae (Fig. 71); *mandibles* each with 10-11 teeth on inner margin of outer canine (Fig. 99).
Thorax: Dark brown, pronotum with large pale areas near lateral margins; *legs* mostly brown with irregular white areas on femora, claws without pectinations (Fig. 118).
Abdomen: Ground color brown; *terga* 6 and 8-10 usually with much more brown than other terga (Fig. 26); *sterna* 4-8 pale usually with broad dark brown crossbands on median portions near anterior margins, sternum 9 dark brown at posterior margin and near each lateral margin (Fig. 43); *posterolateral angles* of segments 3 (or 4)-9 extended as spines; *Caudal filaments* yellow or tan.

MALE IMAGO (Figs. 136 and 137): See Burks (1953) or Traver (1935) for complete description.
Fore wing hyaline, stigmatic area shaded with red-brown, cross veins in bulla region crowded in first six interspaces (Fig. 158); *genitalia* are shown in Fig. 181.

ECOLOGY AND DISTRIBUTION

This species is common in the mountains of the eastern states from New York to North Carolina and Tennessee (Fig. 198). Reports from states west of the Mississippi and Ohio Rivers are questionable. All specimens labeled *S. pudicum* from the central states (Illinois and Oklahoma) that I have examined were misidentified specimens of *S. tripunctatum* and *S. nepotellum*. Present evidence indicates that *S. pudicum* is intolerant of pollution.

Specimens Examined: NORTH CAROLINA — Yadkin River, Blowing Rock, 23V40, 1 nymph (Frison). PENNSYLVANIA — E. Branch White Clay Creek, Avondale, 26V70, 2 males, 1 female (reared) (Richardson); same location, 16XII69, 1 male (reared) (Richardson); Marvina Creek, Marvindale, 23VII69, 1 nymph (Lewis); Minister Creek, Sheffield, 23VII69, 1 nymph (Lewis). TENNESSEE — Little Pigeon River, Greenbrier Cove, 7V39, 1 female, 1 male (Cole). VIRGINIA — Lynch River, Standardsville, 21III40, 1 nymph (Frison and Mohr). DISTRICT OF COLUMBIA—Washington, no date (1858), 1 male ("Type") (Hagen).

DISCUSSION

Traver (1935) noticed that imagos of *S. pudicum* from South Carolina lacked the sagittate dark median marks so characteristic of specimens from further north. She chose to hold these specimens as *S. pudicum* because the nymphs were not yet known. Recently Carlson (Florida A&M University) (personal communication) reared adults of this light phase from nymphs taken from Wildcat Creek, South Carolina, and found striking differences in the nymphal mouthparts. Therefore, this southern form has been described as *S. carlsoni* (Lewis, 1974).

Stenonema pulchellum **(Walsh)**

(Figures 12, 13, 49, 66, 91, 92, 114, 143, 156, 178)

Palingenia pulchella Walsh, 1862: 375
Stenonema pulchellum Traver, 1935: 327; Burks, 1953: 179

NYMPH: Length 7-9 mm.

Head: Dark brown freckled with numerous white dots, pale spot lateral to each compound eye and on meson at posterior margin; *maxilla* with 4-6 pectinate spines but without setae on crown, 20-30 lateral setae (Fig. 66); *mandibles* each with 6-7 teeth on inner margin of outer canine (Figs. 91 and 92).

Thorax: Brown, pronotum with 2 or 3 large pale spots near each lateral margin; *legs* white, each femur with 2 brown bands dorsally, each tibia with basal and median dark-brown bands, basal half of tarsi brown, claws pectinate (Fig. 114).

Abdomen: Distinct pattern of brown and white areas; *terga* 6, 8, and 10 almost entirely dark brown, terga 1-5 white with brown markings, tergum 7 mostly white with brown markings near lateral margins and on meson, tergum 9 brown with large submedian white areas; *sterna* 1-8 entirely white, sternum 9 white with brown lateral margins (Fig. 49), sterna 8 and 9 sometimes with median brown spot at anterior margins; *gills* 1-6 truncate at apices (Fig. 12); 7th gill with fringe of hairs but without tracheae (Fig. 13); *posterolateral angles* of segments 7-9 extended as spines; *caudal filaments* brown basally, alternating pairs of light and dark segments apically.

MALE IMAGO (Fig. 143): See either Traver (1935) or Burks (1953) for complete description.

Fore wing hyaline, pale brown stain in stigmatic area, cross veins not crowded (Fig. 156); *genitalia* with apical spine usually larger than subterminal spine (Fig. 178).

ECOLOGY AND DISTRIBUTION

S. pulchellum nymphs are very common in streams in the Ohio River Basin where there is moderate current. The distribution of *S. pulchellum* parallels *S. interpunctatum* s.s. forming a half circle beginning in Ontario and extending south of the Great Lakes and ending in Wisconsin and Minnesota (Fig. 199). It is most common in the 4 states at the bottom of the half circle. Nymphs of this species, listed as facultative by Gaufin (1958), are quite tolerant to pollution. They were common in baskets that had a septic odor when recovered from the bottom of the Little Miami River. Nymphs were collected in both clean water and in polluted reaches during this study where the TDS ranged from 255 800 ppm and the pH ranged between 7.5-8.5.

Specimens Examined: ILLINOIS — Vermilion River, Danville, 23V67, 1 nymph (Anderson); Rock Island, no date, 1 male (Type) (Walsh). INDIANA — Flatrock Creek, Omar, 4VIII69, 2 nymphs (Lewis); Mississinewa River, Peru, 11X66, 1 nymph (Anderson); Sand Creek, Columbus, 6V70, 1 nymph (Lewis); Wabash River, Lockport, 5VIII69, 1 nymph (Lewis). KENTUCKY — Cumberland River, Cumberland Falls, 24IX69, 2 nymphs (Lewis). OHIO — Kain Run, Williamsburg, 17V71, 1 male (Lewis); same location, 27V71, 1 female (Lewis); Little Miami River, Cincinnati, 6VI67, 1 male, 6 females, 2 nymphs (Lewis); same location, 18VII68, 5 males, 5 females, 1 nymph (Lewis); same location, 16I69, 1 male (reared), 2 nymphs (Lewis); Little Miami River, Batavia, 18I169, 1 nymph (Lewis); Mad River, West Liberty, 17IX69, 1 nymph (Lewis); Ohio River, Cincinnati, 4XII67, 1 male (reared) (Mason); Turkey Run Creek, Friendship, 6X69, 1 nymph (Lewis).

DISCUSSION

Past separation of the adults of *S. pulchellum* and *S. rubrum* was based almost entirely on color characters, a practice that has been found to be unreliable in other groups. Only slight differences could be discovered in the genitalia of museum specimens identified as these species by Burks and McDunnough. Although the characters used to separate adults of *S. pulchellum* and *S. rubrum* in this key are not entirely satisfactory, the nymphs are easily separated by characteristics of the mouthparts. There was very little variability among two dozen *S. pulchellum* nymphs collected from the Little Miami River and reared to adults, and both forms keyed out well using the present key. Additional study is needed to determine if the 2 species are part of a polytopic complex of subspecies such as occurs in *S. interpunctatum.*

Stenonema quinquespinum **Lewis**

(Figures 24, 50, 65, 104, 138, 176)

Stenonema quinquespinum Lewis, 1974: 353

NYMPH (Fig. 24): Length 9-10 mm.

Head: Anterior to eyes and on vertex between eyes dark brown with numerous freckle-like white dots, some of white dots converge forming irregular pale spots. Area lateral to compound eye divided into 2 large pale spots by a brown band; each ocellus surrounded by large pale spot (middle one shaped like arrowhead), a small pale spot on vertex near posterior margin of head. Scape of antenna pale, following 2 segments black, and remainder of antenna pale; *maxilla* with 4-6 (usually 5) pectinate spines but without setae on crown, 20-30 lateral setae (Fig. 65); *mandibles* each with 7-8 teeth on inner margin of outer canine (Fig. 104).

Thorax: Brown with a few small pale spots mostly in the mid-dorsal region, large pale spots at each lateral margin of pronotum extending anteromedially nearly to the anterior margin, a large pale spot near anterior margin midway between lateral margin and mid-dorsal line, *legs* with pale femora each with 2 or 3 irregular brown bands across dorsal surface and some brown shading at apex, each tibia with a basal and median brown band, basal half of each tarsus brown, a dense row of hairs along posterior margins of fore legs, claws not pectinate.

Abdomen: With *terga* 1 and 2 mostly white, terga 7 and 9 pale on meson but dark brown laterally and with brown submedian spots near anterior margins, terga 6, 8, and 10 mostly brown with segment 10 darkest, remaining terga brown with pale dots posteriorly and wide pale areas near anterior margins; *sterna* 1-7 pale usually without dark markings, segments 8-9 usually with brown bands near lateral margins and brown spot on meson at anterior margins, segment 9 sometimes with brown band around posterior margin (Fig. 50); *gills* 1-6 truncate at apices, 7th gill with fringe of hairs but without tracheae; *posterolateral angles* of segments 7-9 produced as spines, those on segment 9 very small; *caudal filaments* banded with 2 segments pale and 2 segments brown alternating for length of filaments.

MALE IMAGO (Fig. 138): Length 9 mm.

Head: Below antennal sockets white, vertex yellow with varying amounts of orange shading especially on posterior portion, eyes grey in life turning black in alcohol.

Thorax: Yellow-brown, pale area on meson of mesonotum, pleuron white with pink or orange areas near coxae; *mesoscutellum* white; *legs* with fore femora light tan, remainder of legs white, each femur with red-brown bands at middle and apex, apex of each tibia black, fore tarsal ratio 1.6;

fore wing hyaline, stigmatic area stained with red-brown; *hind wing* with narrow brown band at apical margin.

Abdomen: White; *terga* 2-7 each with a narrow black line at posterior margin and small oblique black spiracular spots, terga 8-10 alabastar white especially in mid-dorsal area; *genitalia* with apical and discal spines (Fig. 176); *caudal filaments* white with dark brown joints.

ECOLOGY AND DISTRIBUTION

Nymphs inhabit middle reaches of medium sized rivers from Georgia to Wisconsin (Fig. 198). Most of the streams from which this species was collected were effected by agricultural runoff and mild organic enrichment. However, this species is often replaced by *S. pulchellum* in more polluted areas below sewage discharges.

Specimens Examined: GEORGIA — Oostanaula River, Rome, 15VII39, 2 males (Fattig) (these specimens were labeled *S. exiguum* and were presumed to be topotypes of that species). INDIANA — Wildcat Creek, Carroll Co., 4VII69, 2 nymphs (Lewis). OHIO — East Fork Little Miami River, Williamsburg, 1V72, 10 males (reared), 10 females (reared), 5 nymphs (includes Holotype, Allotype, and Paratypes) (Lewis). WISCONSIN — Clam River, Burnett Co., 31V72, 1 male (Flowers); same location, 26VI72, 1 nymph (Flowers).

DISCUSSION

Stenonema quinquespinum is closely related to *S. exiguum* and *S. pulchellum*. However, *S. quinquespinum* can be separated from *S. pulchellum* by the narrow apical brown border on the hind wing and the absence of terminal spines on penis lobes. The presence of dark stigmal spots separates this species from *S. exiguum*, and differences in spination of penis lobes also appear to be diagnostic. Each penis lobe of *S. exiguum* has a subterminal spine, whereas *S. quinquespinum* possesses a discal spine. Differences in wing veination and genitalia separate this species from *S. integrum*, and the absence of 2 dark dashes at the posterior margins of terga 2-8 serve to distinguish it from *S. ares* and *S. bipunctatum*.

Nymphs could be confused with *S. exiguum* except for the lack of pectinations on the claws. They are separated from *S. pulchellum* by the band of large white spots across the mesonotum at the wing bases.

Stenonema rubromaculatum (Clemens)

(Figures 30, 40, 76, 103, 113, 183)

Heptagenia rubromaculata Clemens, 1913: 256
Ecdyonurus rubromaculatus McDunnough, 1933: 16
Stenonema rubromaculatum Traver, 1935: 329; Burks, 1953: 178

NYMPH (Fig. 30): Length 8-10 mm.

Head: Dark brown sprinkled with small pale dots, lateral margins pale in posterior half, this pale area cut in half by a transverse dark band; *maxilla* with 4-6 pectinate spines and 30-50 setae on crown, 20-35 lateral setae (Fig 76); *mandibles* each with 8-9 teeth on inner margin of outer canine (Fig. 103).

Thorax: Dark brown sprinkled with small pale dots; *legs* very hairy at posterior and anterior margins, dorsum of each femur with 4 irregular dark bands separated by pale areas, white ventrally, claws pectinate (Fig. 113).

Abdomen: Brown; *terga* sprinkled with many small pale dots, without conspicuous color pattern; *sterna* pale with dark markings variable, usually with 2 pairs of median dots and a pair of lateral dots, these dots often joined by an oblique dark line, in dark-phase nymphs (midsummer) the space between dots and oblique band fills with dark pigment forming mushroom-like markings similar to *S. ithaca* (Fig. 40), sternum 9 with dark lateral borders and a dark streak, or blotches, near anterior margin forming 3 sides of a square; *gills* 1-6 truncate at apices, 7th gill with fringe of hairs but without tracheae; *posterolateral angles* of segments 3-9 extended as spines; *caudal filaments* brown.

MALE IMAGO: Length 8-9 mm.

Head: Whitish on face with faint dark dash on each side of carina below antennae, vertex pale creamy-yellow.

Thorax: Light olive gray or pale clay colored, *mesoscutellum* white; *legs* white with median and apical dark bands on femora; fore tarsal ratio 1.6-2.2; *fore wing* hyaline with reddish shading in stigmatic area, cross veins in bulla region moderately crowded (usually 2, 2, 3 in costal, subcostal, and radial interspaces respectively); *hind wing* without dark band at apex.

Abdomen: *Terga* 1-7 hyaline, a narrow transverse dark band across posterior margin of each, terga 8-10 opaque white shaded with pinkish brown near median line, in dark-phase males this brown shading also covers half or more of terga 2-7 as in *S. fuscum*, dark spiracular dots on terga 2-7; *genitalia* similar to *S. nepotellum* with a hook-like terminal spine and a minute apical spine on each penis lobe (Fig. 183); *caudal filaments* white with dark brown joints.

ECOLOGY AND DISTRIBUTION

The distribution of this species is restricted to the northeastern United States and southeastern Canada (Fig. 200) corresponding to that of *S. interpunctatum frontale*. Nymphs inhabit small streams where there is moderate to fast current. Although I collected several of these nymphs in a very small stream clinging to the bottoms of rocks where the water was only an inch deep and nearly stagnant, I have never collected specimens from polluted waters. They are probably clean-water forms.

Specimens Examined: ILLINOIS—Vermilion River, Oakwood, 6VI25, 1 male, 1 female (McDunnough). MAINE — Carsley Brook, Harrison, 2VII69, 1 female, 1 nymph (Lewis); same location, 12VII71, 1 male, 3 females (reared), 3 nymphs (Lewis); Crooked River, Harrison, 14VII71, 1 nymph (Lewis). PENNSYLVANIA—Avondale, 28VI70, 1 male (Richardson); same location, 4VI70, 1 male (Richardson). VERMONT — Brown River, Essex Center, 2X60, 1 nymph (Bean). CANADA—South Bolton, Quebec, 20VI30, 1 female (Milne); Go-Home River, Ontario, no date, 1 male (Holotype), 1 female (Allotype) (Clemens); same location, 10VII32, 1 male (reared) (Walley); Severn, Ontario, 22VI25, 1 male (McDunnough).

DISCUSSION

The two color phases exhibited by both the nymphs and adults of this species have been primarily responsible for the confusion concerning the taxonomy of this species, which has been variously identified as *S. ithaca*, *S. fuscum*, *S. pulchellum*, or *S. nepotellum*. The light phase adult is very similar to *S. pulchellum* and *S. nepotellum*, and the dark phase has been confused with *S. fuscum*. Light-phase nymphs are usually quite easy to identify, but the dark phase has been identified as *S. ithaca* by most previous workers. Both phases can be properly placed by using the characters in the keys of this manual. It has been suggested (and it is admittedly possible) that the light and dark phases are two distinct species. At present, I consider them variants of one species. I have collected nymphs of the dark phase of *S. rubromaculatum* and nymphs of *S. ithaca* from the same streams near Ithaca, New York, thinking that everything I was collecting was *S. ithaca*. Upon rearing the nymphs, I found that

2 species were involved and found, upon close study of the nymphal mouth parts, that these nymphs could be easily separated by the presence or absence of setae on the crowns of the maxillae.

Stenonema rubrum (McDunnough)

(Figures 32, 51, 74, 100, 112, 164, 185)

Ecdyonurus ruber McDunnough, 1925: 192
Stenonema rubrum Traver, 1935: 330; Burks, 1953: 178
Stenonema varium Traver, 1933: 192; 1935: 333 NEW SYNONYMY

NYMPH (Fig. 32): Length 8-9 mm.
Head: Brown with 2 pale areas lateral to compound eyes; *maxilla* with 4-5 pectinate spines and 15-35 setae on crown, 15-25 lateral setae (Fig. 74); *mandibles* each with 7-9 teeth on inner margin of outer canine (Fig. 100).
Thorax: Brown; *legs* brown banded with obscure pale areas, claws pectinate (Fig. 112).
Abdomen: Often uniform brown; *terga* sometimes with median lighter spots faintly indicated especially on tergum 7; *sterna* 1-7 usually entirely white, sternum 8 often with a median dark brown spot at anterior margin (on southern forms this spot usually expanded to form a crescent-shaped crossbar on sterna 7 and 8 as in Fig. 51), sternum 9 with U-shaped dark brown mark open posteriorly; *gills* 1-6 truncate at apices, 7th gill with fringe of hairs but lacking tracheae; *posterolateral* angles of segment 7-9 extended as spines; *caudal filaments* uniformly tan except beyond the middle where alternating pairs of segments are light and dark.

MALE IMAGO: See Burks (1953) for complete description.
Fore wing hyaline, faint pink shading in stigmatic area, no crowding of cross veins in bulla area (Fig. 164); *genitalia* with apical and subterminal spines similar in size and shape (Fig. 185).

ECOLOGY AND DISTRIBUTION

S. rubrum is common west and north of the Great Lakes where its distribution parallels that of *S. interpunctatum canadense;* it extends through the Appalachian Mts. to Florida (Fig. 201). It seems to be very common in Minnesota and Wisconsin where it inhabits rivers and larger streams with moderate to fast current. Bell (1969) found the nymphs of this species numerous on bedrock, rubble, and coarse gravel (212 to 261 per sq. m.) and rare on coarse sand substrate. The pollution tolerance of *S. rubrum* seems to be similar to *S. pulchelium*. Bell and Nebeker (1969) found this species moderately tolerant of low pH with a mean 96-hour TLM of pH 3.32.

Specimens Examined: ILLINOIS — Middle Fork Vermilion River, Penfield, 13X65, 1 nymph (Anderson). INDIANA — Big Walnut Creek, Greencastle, 6VIII69, 1 nymph (Lewis). MICHIGAN — Pere Marquette River, Lake Co., 2VII47, 1 male (Leonard). MINNESOTA — Blackhoof River Carlton Co., 2XI64, 1 nymph (Bell). NORTH CAROLINA — Big Alamance Creek, Toms Place, 5IV30, 1 male (reared) (Holotype of *S. varium*) (Traver); Caraway Creek, Sophia, 17IV30, 1 male, 1 female (reared) (Paratypes of *S. varium*) (Traver). WISCONSIN—Oconto River, Oconto Co., 28V69, 1 nymph (Hilsenhoff); Rocky Creek, Wood Co., 5VIII68, 1 nymph (Hilsenhoff); Macan River, Waushara Co., 7IV72, 1 male (reared) (Flowers). CANADA—Go-Home-Bay, Ontario, 19VI32, 1 male (Walley); Gatineau Lake, Wakefield, Quebec, 13VI30, 1 male (reared) (McDunnough); Ottawa Golf Club, Quebec, 31VII24, 1 male (Holotype) (Walley).

DISCUSSION

Although adults of this species are very similar to *S. pulchellum*, the nymphs are easily separated as discussed under that species.

Synonymization of *S. varium* with this species resulted from a comparison of the type series of both species. Although the genitalia of the type of *S. varium* were missing, I have examined the genitalia of other specimens from the southeast and found them to be similar to *S. rubrum*. The fore tarsal ratio averages slightly greater and the cross veins are usually less crowded in *S. varium* than in *S. rubrum*, but these characters are not sufficiently constant to justify speciation. Nymphs from the 2 populations differ only in intensity of dark coloration and cannot usually be separated.

Stenonema smithae Traver

(Figures 31, 52, 73, 106, 146, 159, 179)

Stenonema smithae Traver, 1937: 77; Berner, 1950: 59

NYMPH (Fig. 31): Length 7-9 mm.
Head: Dark brown, frontal portion thickly freckled with small pale dots, area lateral to compound eyes pale, 3 pale spots on vertex near ocelli; *maxilla* with 4-6 pectinate spines and 30-40 setae on crown, 20-30 lateral setae (Fig. 73); *mandibles* each with 7-8 teeth on inner margin of outer canine (Fig. 106).
Thorax: Dark red-brown, a few pale markings on pronotum, median pale line on mesonotum; *legs* dark brown, irregular pale blotches forming bands across each femur, claws pectinate.
Abdomen: Mostly dark brown; *terga* 1-5 pale laterally, large submedian pale spots on tergum 7; *sterna* 1-8 pale often with dark bars and dots, sternum 9 with brown streaks along lateral margins, a faint median dot at anterior margin and transverse dashes extending from this dot (Fig. 52); *gills* 1-6 truncate at apices, 7th gill with fringe of hairs but without tracheae; *posterolateral angles* of segments 7-9 extended as spines; *caudal filaments* brown at base becoming yellow with brown joints near middle, apically with 3 dark segments alternating with 1 pale segment.

MALE IMAGO: Length 7-8 mm.
Head: White, a faint transverse band across median carina.
Thorax: Flesh colored or yellowish white; *mesoscutellum* white: *legs* yellow, each femur with dark apical and median bands; fore tarsal ratio 1.7-2.1; *fore wing* hyaline, veins dark brown, cross veins in bulla region only slightly crowded; *hind* wing with apical margin very narrowly dusky (Fig. 159).
Abdomen: Pale yellowish; *terga* with dark spiracular dots and black posterior margin on each (Fig. 146); *genitalia* with small apical spine and minute terminal spine on each penis lobe (Fig. 179); *caudal filaments* white, alternating joints darkened.

ECOLOGY AND DISTRIBUTION

Berner (1950) made a thorough study of the life history and ecology of the species in Florida. He found nymphs in all types of permanent streams of the Coastal Plain of northern Florida. He recently found nymphs on rocks along the shore of highly eutrophic Lake Okeechobee (personal communication). They were found in water with pH ranging from less than 4 to 7.8 and temperatures up to 30°C. This would put *S. smithae* in the facultative group of insects; however, Beck (1954) considered the species to be a clean-water form.

Specimens Examined: ALABAMA—Tuscaloosa, 1VII36, 1 male (Holotype), 2 males (Paratypes) (Traver). FLORIDA — Comfort Creek, Quincy, 1X67, 2 males (Peters, Tsui, and Jones); same location, 10VIII67, 2 males, 2 females (Cooper, Jones and Owens); Flat Creek, Chattahoochee, 24VII67, 1 nymph (Cooper and Jones). MAINE — Crooked River, Harrison, 14VII71, 3 males (Lewis).

DISCUSSION

This species is very close to *S. rubromaculatum*, but differences in the genitalia of the male and the arrangement of spines and setae on the nymphal maxillae will separate the 2 species. All published records for *S. smithae* are for Alabama and Florida, and until recently, it has been considered the only species of *Stenonema* restricted to the southern United States (Fig. 197). However, this distinction is now questioned because of three males I collected in July 1971, at Harrison, Maine, which fit the description of this species, and because of a report that the species may inhabit Pennsylvania (J. Richardson — personal communication). It is hoped that this question can be answered by rearing nymphs from the Crooked River, Maine.

Stenonema terminatum (Walsh)

(Figures 21, 48, 62, 89, 116, 173)

Palingenia terminata Walsh, 1862: 376; 1863: 203
Stenonema terminatum Traver, 1935: 331; Burks, 1953: 175

NYMPH: Length 9-10 mm.

Head: Dark brown with many freckle-like dots, brown band separating 2 large pale spots lateral to each compound eye, pale spot near each ocellus and on vertex at posterior margin; *maxilla* with 4-6 strongly pectinate spines but without setae on crown, 15-25 lateral setae (Fig. 62); *mandibles* each with 5-7 teeth on inner margin of outer canine (Fig. 89).

Thorax: Brown with many small pale spots mostly clustered on meson; *legs* about equally white and brown, anterior margins hairy; each femur with 2 irregular brown bands alternating with 3 white bands dorsally, reddish-brown near apex; claws not pectinate (Fig. 116).

Abdomen: Brown with pale dots (Fig. 21); *terga* 1 and 2 mostly pale, tergum 9 with large pale median spot; *sterna* 2-9 usually with paired submedian posteriorly-diverging dashes becoming larger and darker on more posterior segments (Fig. 48), sternum 9 (often 8 also) with brown shading around posterior and lateral margins; *gills* 1-6 truncate at apices; 7th gill with fringe of hairs but without tracheae; *posterolateral angles* of segments 7-9 extended as spines; *caudal filaments* pale near bases, usually becoming banded alternately light and dark beyond middle.

MALE IMAGO: See Burks (1953) for complete description.
Genitalia illustrated in Fig. 173.

ECOLOGY AND DISTRIBUTION

Nymphs of *S. terminatum* inhabit coarse sand and gravel substrates in larger streams of the north central states (Fig. 200). They were abundant in the Scioto River at Portsmouth, Ohio, during the summer of 1969, and appeared unaffected by the polluted conditions that existed at the time (Lewis, 1973). Two male imagos and 2 nymphs from western Canada, very similar to *S. terminatum*, are tentatively placed here, although they may represent a new species.[1]

Specimens Examined: ILLINOIS — Rock River, Rockford, 4IX40, 1 male (Burks); same location, 22V41, 1 male (Ross and Burks); Rock Island, no date, 1 male, 1 female (Types) (Walsh). INDIANA — Moots Creek, Ash Grove, 5VIII69, 1 male, 3 females (Lewis); Wildcat Creek, Prymont, 4VIII69, 1 male, 1 female (subimagos) (Lewis). OHIO—Ohio River, Portsmouth, 12IX68, 2 nymphs (Lewis), Ohio River, Cincinnati, 22VIII70, 1 male (reared) (Lewis); Scioto River, Portsmouth, 6V70, 1 nymph (Lewis); same location, 5V70, 7 males (reared), 14 females (reared), 25 nymphs (Lewis); same location, 12IX68, 1 male, 1 nymph (Lewis). CANADA—Aweme, Manitoba, 11VI23, 1 male (Homotype) (White); Okanagan Landing, British Columbia, 2VII34, 2 nymphs (Gartrell); Summerland, British Columbia, 8VII33, 1 male (Gartrell).

DISCUSSION

The identity of the nymph of *S. terminatum*, described by Lewis (1973), was established by rearing 5 males and 20 females from the Scioto River, Portsmouth, Ohio. These adults were compared with the holotype from Illinois. Both imagos and nymphs superficially resemble *S. ares*, and the adults could easily be confused with *S. bipunctatum* and *S. integrum*, all of which occur in the type locality. Characters used in the key of this manual have proven adequate to separate both mature nymphs and male imagos of these closely related species.

Burks (1953) synonymized *S. placitum* (Banks) with *S. terminatum*, but a careful examination of the genitalia of the types has revealed important differences in the 2 species resulting in resurrection of *S. placitum*.

Stenonema tripunctatum (Banks)

(Figures 19, 39, 61, 88, 127, 151, 154, 155, 171)

Heptagenia tripunctata Banks, 1910: 199
Stenonema tripunctatum Traver, 1935: 332; Burks, 1953: 168
Stenonema scitulum Traver, 1935: 330
Stenonema femoratum tripunctatum Spieth, 1947: 99
Stenonema femoratum scitulum Spieth, 1947: 100 NEW COMBINATION

NYMPH (Fig. 19): Length 8-12 mm.

Head: Ground color tan or light brown freckled with pale dots, anterior margin usually with a median and a pair of sublateral pale spots; *maxilla* with 3-5 pectinate spines and 10-30 setae on crown, 20-40 lateral setae (Fig. 61), *mandibles* each with 5-8 teeth on inner margin of outer canine (Fig. 88).

Thorax: Brown with a few pale dots, area lateral to compound eyes usually mostly pale; *legs* brown with large irregular white areas on dorsum of femora, basal and median brown bands on tibiae, claws pectinate.

Abdomen: Brown usually distinctively marked with white or yellow; *terga* 1 and 5 have pale "X-shaped" spots nearly covering median area, a larger "X-shaped" spot covers terga 8 and 9; *sterna* 2-8 usually with a pair of sublateral brown spots, sternum 9 with 2 pairs of brown spots laterally and a pair of much larger brown spots at posterolateral angles (Fig. 39); *gills* 1-6 rounded at apices, 7th gill with tracheae and fringed with hairs; *posterolateral angles* of segments 3-9 extended as large spines; *caudal filaments* yellow at bases, alternating pairs of light and dark segments in middle and apical areas.

MALE IMAGO (Fig. 127): See Burks (1953) for detailed description. Traver (1935) gives a good description of *S. tripunctatum scitulum*.

Fore wing hyaline, stigmatic area shaded with brown, cross veins crowded in bulla region (Fig. 154); *hind wing* either with dark apical margin as in Fig. 151 *(S. t. scitulum)* or without dark apical margin as in Fig. 155 *(S. t. tripunctatum)*; *genitalia* as in Fig. 171.

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[1] A new species closely related to *S. terminatum* is being described by Jensen and Edmunds (personal communication).

ECOLOGY AND DISTRIBUTION

This species is common in lakes and pools of streams over much of the United States (Fig. 202). It has been reported from Canada to Texas and from New York to Oregon. However, the Oregon record has been questioned by Allen and Edmunds (1956). Most specimens from Arkansas and Oklahoma labeled *S. tripunctatum* that I have examined were the subspecies *scitulum*, which indicates that this subspecies is more common than published reports indicate. The nymph of this species was by far the most common mayfly in Shayler Run, a small hard water stream near Cincinnati, Ohio, receiving effluent from a sewage treatment plant and containing high concentrations of TDP (1.5 mg/l mean yearly average) and TDS (450 mg/l mean yearly average). Other streams from which this species was collected exhibited pH ranging between 7.5-8.0 and TDS ranging from 250-500 mg/l. However, in all cases the DO levels (> 6.0 mg/l) and temperatures (< 25.0°C) were not limiting (Nebeker and Lemke, 1968).

Specimens Examined: *Stenonema tripunctatum tripunctatum:* KENTUCKY — Boiling Spring Creek, Munfordville, 8VIII69, 2 nymphs (Lewis); Paint Lick Creek, Kirksville, 15VIII69, 2 nymphs (Lewis); W. Fork Drakes Creek, Franklin, 25V71, 3 females (reared), 1 male (Myers). MINNESOTA — Pine River, Pine River, 18VIII35, 1 female (Daggy). MISSOURI — Roaring River, Roaring River State Park, 8VII57, 1 nymph (Peters). NEW YORK — Westerfield, 13VI05, 1 male (Type) (Banks). OHIO — Kain Run, Williamsburg, 27V71, 1 female, 1 nymph (Lewis); Little Miami River, Newtown, 18V68, 1 female (Lewis); Ohio River, Cincinnati, 7VIII68, 1 nymph (Lewis); Shayler Run, Union Township, 28V69, 1 male (Mason); same location, 23IV71, 1 male (reared) (Lewis); Stillwater River, Beamsville, 17IX69, 1 nymph (Lewis). OKLAHOMA — Comanche Co., 28II32, 1 male, 1 female, 1 nymph (Holotype and Paratypes of *S. birdi*) (Bird); Spavinaw Creek, Spavinaw, 11VII57, 1 nymph (Peters). WISCONSIN — Milwaukee, 22VII09, 1 male (Type) (Banks). CANADA — Lake Winnipeg, Manitoba, 15X69, 1 nymph (Flannagan); Knowlton Creek, Knowlton, Quebec, 11IX30, 1 female (Milne).

Stenonema tripunctatum scitulum: ARKANSAS — Washington Co., 15IV56, 1 male (Peters); Cove Creek, Washington Co., 22V62, 1 male (Hite). KENTUCKY — Boiling Spring Creek, Munfordville, 8VIII69, 1 male (reared) (Lewis); Paint Lick Creek, Kirksville, 15VIII69, 1 male (reared) (Lewis); W. Fork Drakes Creek, Franklin, 24VIII71, 1 male (Myers). OHIO — Kain Run, Williamsburg, 18V71, 2 males (Lewis); same location 27V71, 1 male (reared), 4 females (reared) (Lewis); Shayler Run, Union Township, 7VI69, 2 males (reared), 3 females (reared) (Mason); same location, 13VI69, 1 female (Lewis); same location, 4XII69, 1 nymph (Mason); same location, 14IV71, 1 male (reared) (Lewis); same location, 23IV71, 1 male (reared), 1 nymph (Lewis). OKLAHOMA — Fourche Maline River, Wilburton, 1VII69, 7 nymphs (Prins); Mountain Fork River, Hochatown, 6V39, 1 male (Waddle); Latimer Co., 20VI31, 1 male (Holotype), 1 female (Paratype) (Bird); Salina Creek, Locust Grove, 12VI57, 1 male (Peters); Spavinaw Creek, Spavinaw, 11VI57, 1 female (Peters).

DISCUSSION

This species consists of 2 subspecies *S. tripunctatum tripunctatum* and *S. tripunctatum scitulum*. In the Ohio River Basin, both subspecies occur in the same streams and intergrades are the rule rather than the exception. Sympatry, however, occurs with *S. femoratum* as discussed under that species. Of 42 *FEMORATUM* group nymphs from Shayler Run near Cincinnati, Ohio, reared to adults, 19 were *S. tripunctatum scitulum*, 6 were *S. tripunctatum tripunctatum*, 6 were *S. femoratum*, and 11 were *S. tripunctatum* x *scitulum* hybrids possessing intermediate characters. The holotypes of the 2 subspecies differ only in size and amount of dark shading in the apical areas of the hind wings. Where the 2 forms occur together, none of these characters are constant. The nymph of *S. tripunctatum scitulum* (recently described in *The Proceedings of the First International Conférence on Ephemeroptera* [Lewis, 1973]) differs only slightly from typical *S. tripunctatum tripunctatum* nymphs.

Daggy (1941) suspected that *S. scitulum* was not distinct from *S. tripunctatum*. Spieth (1947) considered both *S. scitulum* and *S. tripunctatum* to be subspecies of *S. femoratum*, and suggested that *S. tripunctatum* derived from *S. scitulum*, which moved into the Ohio River Basin from the southwest following the last glaciation. *Stenonema femoratum* is a monotypic species; therefore, *S. scitulum* becomes *S. tripunctatum scitulum*.

Stenonema vicarium (Walker)

(Figures 28, 47, 72, 105, 109, 135, 163)

Baetis vicaria Walker, 1853: 565
Stenonema vicarium Traver, 1935: 334; Burks, 1953: 172

NYMPH (Fig. 28): Length 14-18 mm.

Head: Brown freckled with pale dots, area lateral to compound eyes and at posterior margin pale; *maxilla* with 2-4 pectinate spines and 10-30 setae on crown, 15-30 lateral setae (Fig. 72); *mandibles* each with 7-8 teeth on inner margin of outer canine (Fig. 105).

Thorax: Uniform brown except for large pale spots at lateral and anterior margins of pronotum; *legs* pale with irregular brown bands on dorsum of femora, claws not pectinate (Fig. 109).

Abdomen: With brown mid-dorsal band length of abdomen; *terga* 1-10 with broad brown crossband at posterior margins, terga 5 and 6 often almost completely brown, others usually with elongate submedian pale spots; *sterna* white with broad dark brown crossbands at posterior margins, usually apical half or more of sternum 9 brown (Fig. 47); *gills* 1-6 truncate at apices, 7th gill with fringe of hairs but without tracheae; *posterolateral angles* of segments 3-9 extended as spines; *caudal filaments* tan or yellow in basal half, usually dark and light pairs of segments alternating apically.

MALE IMAGO (Fig. 135): See Traver (1935) or Burks (1953) for complete description.

Fore wing hyaline, stigmatic area shaded with red, cross veins moderately crowded in bulla region (Fig. 163); *genitalia* with large apical spine and small subterminal spine on each penis lobe.

ECOLOGY AND DISTRIBUTION

This species is common in most of the eastern United States south to North Carolina, Kentucky, and Illinois, and in eastern and central Canada (Fig. 203). Nymphs inhabit moderate to fast rivers and streams that are not polluted by domestic wastes; however, Leonard (1965) found them in streams polluted by toxic substances. It is the most common species in the small mountain streams of West Virginia.

Specimens Examined: NEW YORK — Sacandaga River, Sport Island, 12VI09, 1 male, 1 female. OHIO — Mad River, West Liberty, 17IX69, 1 nymph (Lewis); Turkey Run Creek, Friendship, 6X69, 1 nymph (Lewis). PENNSYLVANIA—Allegheny River, Coudersport, 24VII69, 1 nymph (Lewis). VERMONT — N. Branch Bridgewater Creek, Bridgewater, 5X63, 1 nymph (Whitney); Potash

Brook, S. Burlington, 12X60, 2 nymphs (Cochran). WEST VIRGINIA — Glady Fork, Glady, 20VII69, 1 nymph (Lewis). CANADA — Stream 40 mi. SE of Kenora, Ontario, 14VI69, 1 male (reared) (Flannagan).

DISCUSSION

Both the nymphs and adults of *S. vicarium* are distinctive and not likely to be confused with other species except *S. fuscum*, to which it is closely related. Characters used in the keys of this manual will separate most specimens.

Burks (1953) synonymized *S. rivulicolum* (McDunnough) with *S. vicarium*. His figures 344 and 346 should be reversed. Figure 346 is the genitalia of *S. vicarium*. There is little doubt that *S. rivulicolum* is intermediate between *S. vicarium* and *fuscum*, but it is herein transferred to *S. fuscum* for reasons given under that species.

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APPENDIX A — PHOTOGRAPHS

Plate I — Figs. 8-13 Gills of the three groups of nymphs.

8, *S. gildersleevei* Kirtland, OH (30X) Fourth gill. 9, *S. gildersleevei* Kirtland, OH (75X) Seventh gill. 10, *S. femoratum* Batavia, OH (50X) Fourth gill. 11, *S. femoratum* Batavia, OH (75X) Seventh gill. 12, *S. pulchellum* Cincinnati, OH (75X) Fourth gill. 13, *S. pulchellum* Cincinnati, OH (50X) Seventh gill.

Plate II — Figs. 14-19 Dorsal maculation of nymphs.

14, *S. interpunctatum* Jerome, IN (10X). 15, *S. candidum* Paratype (20X). 16, *S. gildersleevei* Topotype (6X). 17, *S. carolina* Jerome, IN (8X). 18, *S. femoratum* Batavia, OH (8X). 19, *S. tripunctatum* Batavia, OH (8X).

Plate III — Figs. 20-26 Dorsal maculation of nymphs.

20, *S. luteum* Embarrass R., WI (10X) Identified by Dr. Ide. 21, *S. terminatum* Portsmouth, OH (6X). 22, *S. mediopunctatum* Apple R., WI (10X) Identified by Dr. Ide. 23, *S. exiguum* FL (4X) Note pale band across mesonotum at base of wing pads. 24, *S. quinquespinum* Cincinnati, OH (15X) Note pale seventh tergum. 25, *S. integrum* Madison, IN (4X) Note large white V-shaped patch on terga 7-9. 26, *S. pudicum* Avondale, PA (10X).

Plate IV — Figs. 27-34 Dorsal maculation of nymphs.

27, *S. ithaca* Chicago, NY (8X). 28, *S. vicarium* Honors, MI (3X). 29, *S. fuscum* New Brunswick Province, CANADA (4X). 30, *S. rubromaculatum* Glady, WV (4X). 31, *S. smithae* Avondale, PA (4X). 32, *S. rubrum* (Paratype of *S. varium)* (5X). 33, *S. bipunctatum* Clam R., WI (6X). 34, *S. luteum* Topotype (8X).

Plate V — Figs. 35-39 Ventral maculation of nymphs.

35, *S. interpunctatum* s.s. Noblesville, IN (8X). 36, *S. interpunctatum frontale* Harrison, ME (4X). 37, *S. integrum* Madison, IN (8X).. 38, *S. femoratum* Batavia, OH (6X). 39, *S. tripunctatum* Batavia, OH (4X).

Plate VI — Figs. 40-47 Ventral maculation of nymphs.

40, *S. rubromaculatum* Millport, PA (10X) Note black band near middle of sterna. 41, *S. ithaca* Binghamton, NY (8X) Note marks on sternum 9. 42, *S. nepotellum* Omar, IN (10X). 43, *S. pudicum* Avondale, PA (13X). 44, *S. mediopunctatum* Apple R., WI (4X). 45, *S. luteum* Topotype (13X) Note black posterior band on sternum 8. 46, *S. fuscum* Baptism R., WI (13X) Note black spots at posterolateral angles of sternum 9. 47, *S. vicarium* Honors, MI (6X) Note continuous band across posterior half of sternum 9.

Plate VII — Figs. 48-52 Ventral maculation of nymphs.

48, *S. terminatum* Portsmouth, OH (5X). 49, *S. pulchellum* Markle, IN (6X). 50, *S. quinquespinum* Cincinnati, OH (5X). 51, *S. rubrum* (Paratype of *S. varium*) (10X). 52, *S. smithae* Chattahooche, FL (13X).

Plate VIII — Figs. 53-61 Maxillae (Ventral view).

53, *Heptagenia* sp. Cincinnati, OH (100X) Note lateral setae scattered over surface of galea. 54, *S. carolina* Quebec Province, CANADA (125X) Identified by McDunnough. 55, *S. candidum* Franklin, KY (75X). 56, *S. interpunctatum* Spring Grove, IL (100X). 57, *S. pallidum* Holotype (125X) Arrow indicates pectinate spines on crown. 58, *S. femoratum* Williamsburg, OH (200X) Arrow indicates setae on crown. 59, *S. gildersleevei* Walden Ridge, TN (200X). 60, *S. minnetonka* Williamsburg, OH (125X). 61, *S. tripunctatum* Providence, KY (200X).

Plate IX — Figs. 62-69 Maxillae (Ventral view).

62, *S. terminatum* Cincinnati, OH (200X) Note spines only slightly pectinate. 63, *S. exiguum* Madison, IN (125X). 64, *S. carlsoni* Pine Mt., KY (100X). 65, *S. quinquespinum* Clam R., WI (125X). 66, *S. pulchellum* Cincinnati, OH (200X) Arrow indicates lateral setae. 67, *S. ithaca* Binghamton, NY (125X). 68, *S. nepotellum* Topotype (100X). 69, *S. ares* Greenville, IL (125X).

Plate X — Figs. 70-78 Maxillae (Ventral view).

70, *S. integrum* Cincinnati, OH (400X). 71, *S. pudicum* Avondale, PA (75X). 72, *S. vicarium* West Liberty, OH (125X). 73, *S. smithae* Chattahoochee, FL (125X). 74, *S. rubrum* Popple R., WI (125X). 75, *S. fuscum* Otter Creek, WI (100 X). 76, *S. rubromaculatum* Topotype (125X) Identified by McDunnough. 77, *S. luteum* Ontario Province, CANADA (125X). 78, *S. mediopunctatum* Barron, WI (125X).

Plate XI — Figs. 79-88 Mandibles (Ventral view of left mandible except as noted).

79, *Heptagenia* sp. Cincinnati, OH (125X) Dorsal view. Note more than one lacinia mobilis. 80, *S. minnetonka* Iron R., WI (325X) Ventral view of right mandible. 81, *S. gildersleevei* Paratype (200X). 82, *S. candidum* Paratype (75X) Arrow denotes left outer canine. 83, *S. pallidum* Holotype (250X) Arrow denotes inner canine. 84, *S. carolina* Swannanoa, NC (125X) Dorsal view. Note two blunt teeth on inner margin of inner canine. 85, *S. interpunctatum* s.s. (Holotype of *S. conjunctum*) (200X) Dorsal view. Arrow denotes lacinia mobilis. 86, *S. interpunctatum canadense* Honors, MI (200X). 87, *S. femoratum* Batavia, OH (250X) Dorsal view. 88, *S. tripunctatum* St. Leon, IN (125X).

Plate XII — Figs. 89-98 Mandibles (Ventral view of left mandible except as noted).

89, *S. terminatum* British Columbia Province, CANADA (300X) Dorsal view. 90, *S. bipunctatum* Clam R., WI (300X). 91, *S. pulchellum* Cincinnati, OH (200X) Right mandible. Compare with left mandible (Fig. 92). Note long spine at apex of inner canine and absence of lacinia mobilis. 92, *S. pulchellum* Warsaw, KY (200X) Dorsal view. 93, *S. ithaca* Binghamton, NY (125X) Dorsal view. 94, *S. exiguum* Madison, IN (100X). 95, *S. ares* Wisconsin R., WI (200X). 96, *S. annexum* Fear R., NC (200X) Ventral view of right mandible. 97, *S. integrum* Cincinnati OH (200X) Dorsal view. 98, *S. luteum* Ontario Province, CANADA (200X).

Plate XIII — Figs. 99-108 Mandibles (Ventral view of left mandible except as noted).

99, *S. pudicum* Avondale, PA (125X) Ventral view of right mandible. 100, *S. rubrum* Macan R., WI (325X) Ventral view of right mandible. 101, *S. fuscum* Averill Creek, WI (250X). 102, *S. mediopunctatum* Barron, WI (100X). 103, *S. rubromaculatum* Ontario Province, CANADA (125X) Dorsal view. 104, *S. quinquespinum* Williamsburg, OH (200X). 105, *S. vicarium* NY (200X) Dorsal view of right mandible. 106, *S. smithae* Paratype (325X) Ventral view of right mandible. 107, *S. carlsoni* Anderson Co., SC (200X). 108, *S. nepotellum* Camp Creek, WI (200X).

Plate XIV — Figs. 109-118 Claws of the nymphs.

109, *S. vicarium* Glady, WV (100X). 110, *S. annexum* Fear R., NC (250X) Arrow denotes pectinations on claw. 111, *S. luteum* Ontario Province, CANADA (250X). 112, *S. rubrum* Macan R., WI (325X). 113, *S. rubromaculatum* Ithaca (?), NY (200X). 114, *S. pulchellum* Batavia, OH (200X). 115, *S. ares* Manitoba Province, CANADA (200X). 116, *S. terminatum* Red Cedar R., WI (200X). 117, *S. exiguum* FL (200X). 118, *S. pudicum* Marvindale, PA (125X).

Plate XV — Figs. 119-128 Maculation of male imagos.

119, *S. carolina* Pine Mountain State Park, KY (8X). 120, *S. pallidum* Holotype (7X). 121, *S. candidum* Franklin, KY (8X). 122, *S. interpunctatum canadense* (Paratype of *S. areion)* (6X) Arrow indicates black posterior margin of tergum 5. 123, *S. interpunctatum canadense* Manitoba Province, CANADA (75X) Note black shading in mid-dorsal area. 124, *S. interpunctatum* cf. *frontale* Franklin, KY (7X). 125, *S. interpunctatum canadense* Manitoba Province, CANADA (40X) Arrow indicates black line on face below antenna. 126, *S. interpunctatum* s.s. Franklin, KY (7X). 127, *S. tripunctatum* Batavia, OH (20X) Note three black marks at posterior margin of terga. 128, *S. femoratum* Batavia, OH (30X).

Plate XVI — Figs. 129-137 Maculation of imagos (Males except as noted).

129, *S. ares* Paratype (7X) Note pair of black dashes at posterior margins of middle terga. 130, *S. carlsoni* Athens, GA (4X) Female. 131, *S. ithaca* Paratype (40X) 132, *S. fuscum* (Paratype of *S. rivulicolum*) (15X). 133, *S. bipunctatum* Holotype (10X) Note pair of black dashes at posterior margin of tergum 6. 134, *S. integrum* var. *metriotes* Cincinnati, OH (20X) Female. Note black median dashes at posterior margins of middle terga. 135, *S. vicarium* Dairyland, WI (25X) Note wide dark posterior margins and median bands on terga. 136, *S. pudicum* Avondale, PA (20X) Dorsal view. 137, *S. pudicum* Avondale, PA (20X) Lateral view.

Plate XVII — Figs. 138-147 Maculation of imagos (Males except as noted).

138, *S. quinquespinum* Williamsburg, OH (10X) Note narrow dark apical margin of hind wing and absence of dark posterior margins on terga. 139, *S. integrum* Cincinnati, OH (25X) Lateral view. Note oblique spiracular streaks on terga. 140, *S. integrum* Cincinnati, OH (30X) Dorsal view of female. Note longitudinal line in median area of tergum 6. 141, *S. mediopunctatum* Holotype (10X) Note black median dash at posterior margin of each tergum. 142, *S. luteum* Lafayette Co., WI (30X) Arrow indicates faint oblique spiracular streak. 143, *S. pulchellum* Batavia, OH (20X) Arrow indicates black spiracular dot on tergum 5. 144, *S. luteum* Homotype from Ontario Province, CANADA (10X) Determined by McDunnough. 145, *S. nepotellum* Franklin, KY (15X). 146, *S. smithae* Quincy, FL (25X). 147, *S. fuscum* Richland Co., WI (30X) Arrow denotes dark median band on tergum 5.

Plate XVIII — Figs. 148-155 Wings.

148, *S. carolina* Wardensville, WV (12X) Fore wing. Note thickened basal cross veins in radial space. 149, *S. interpunctatum* Spring Grove, IL (20X) Hind wing. 150, *S. interpunctatum* Spring Grove, IL (12X) Fore wing. Note black bar connecting two cross veins below bulla. 151, *S. tripunctatum scitulum* Batavia, OH (7X) Note crowded cross veins in only first three spaces in bulla area of fore wing and dark apex of hind wing. 152, *S. candidum* Franklin, KY (12X) Fore wing. Note reduction of cross veins in bulla area. 153, *S. femoratum* Batavia, OH (7X) Note crowded cross veins in first six spaces of fore wing and wide dark apical band of hind wing. 154, *S. tripunctatum* s.s. Batavia, OH (12X) Fore wing. Note crowded cross veins in only first three spaces. 155, *S. tripunctatum* s.s. Loveland, OH (16X) Hind wing. Note absence of dark apical band.

Plate XIX — Figs. 156-164 Wings.

156, *S. pulchellum* Cincinnati, OH (16X) Fore wing. 157, *S. exiguum* Topotype (40X) Hind wing. Note faint dark shading at apex. 158, *S. pudicum* Avondale, PA (7X) Note crowded cross veins in first six spaces in bulla area of fore wing and dark apical band of hind wings. 159, *S. smithae* Avondale, PA (10X). 160, *S. integrum* Cincinnati, OH (16X) Fore wing. Note elongate cells distal to bulla area set off by cross veins that form irregular lines across wing. 161, *S. ithaca* Paratype (40X) Fore wing. 162, *S. nepotellum* Franklin, KY (16X) Note slight crowding of cross veins in bulla area of fore wing. 163, *S. vicarium* Dairyland, WI (8X) Note moderate crowding of cross veins in bulla area of fore wing. 164, *S. rubrum* Paratype (10X).

Plate XX — Figs. 165-172 Male genitalia (Dorsal view).

165, *S. pallidum* Holotype (300X) Arrow denotes subapical spine. 166, *S. floridense* Blackman, FL (125X) Note large axial spines (Arrow). 167, *S. candidum* Franklin, KY (200X). 168, *S. gildersleevei* Kirtland, OH (200X). 169, *S. interpunctatum canadense* Ontario Province, CANADA (125X) Arrow denotes lateral spines on right penis lobe. 170, *S. carolina* Topotype (200X) Note very minute lateral spines on penis lobe. 171, *S. tripunctatum* Prairie Grove, AR (100X) Note straight apical margins. 172, *S. femoratum* Batavia, OH (125X).

Plate XXI — Figs. 173-180 Male genitalia (Dorsal view).

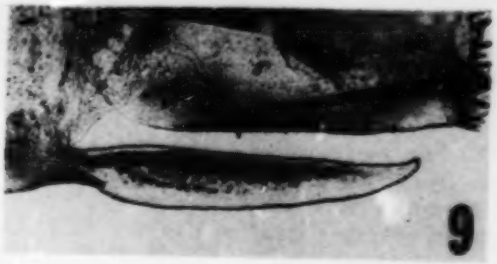
173, *S. terminatum* Portsmouth, OH (200X). 174, *S. modestum* Holotype (400X) Arrow indicates discal spine. 175, *S. annexum* Franklin, KY (125X) Arrow indicates mesal spine. 176, *S. quinquespinum* Williamsburg, OH (300X). 177, *S. integrum* Cincinnati, OH (200X). 178, *S. pulchellum* Batavia, OH (325X). 179, *S. smithae* Paratype (325X). 180, *S. placitum* Holotype (325X).

Plate XXII — Figs. 181-188 Male genitalia (Dorsal view).

181, *S. pudicum* NC (200X). 182, *S. ithaca* Salmon Creek, NY (325X). 183, *S. rubromaculatum* Ontario Province, CANADA (125X). 184, *S. fuscum* Holotype (100X). 185, *S. rubrum* Paratype (400X). 186, *S. nepotellum* Topotype (125X). 187, *S. bipunctatum* Paratype (600X) Arrow indicates terminal spine. 188, *S. luteum* Ontario Province, CANADA (300X) Arrow indicates apicomesal spine.

NOTE: Because the plates were reduced in size during printing, the magnification factors given are approximately 28 percent greater than actual size. A 2-cm scale is provided on each plate to represent this reduction.

8



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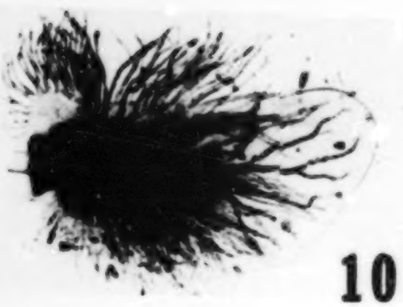

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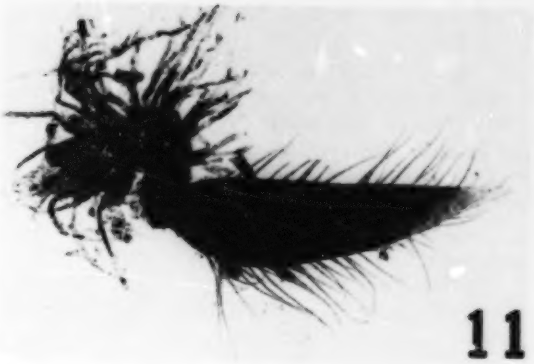

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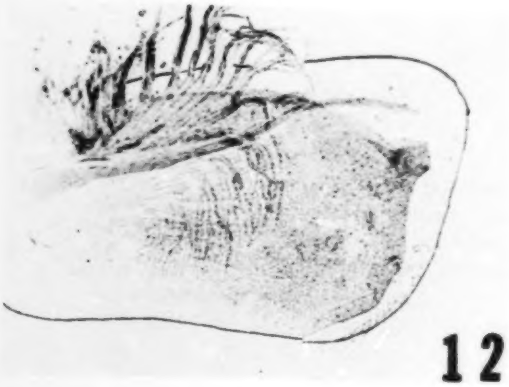

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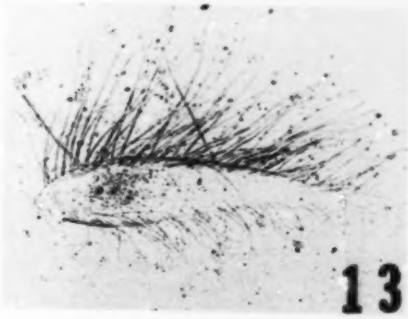

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PLATE 1 — FIGS. 8-13 GILLS OF THE THREE GROUPS OF NYMPHS

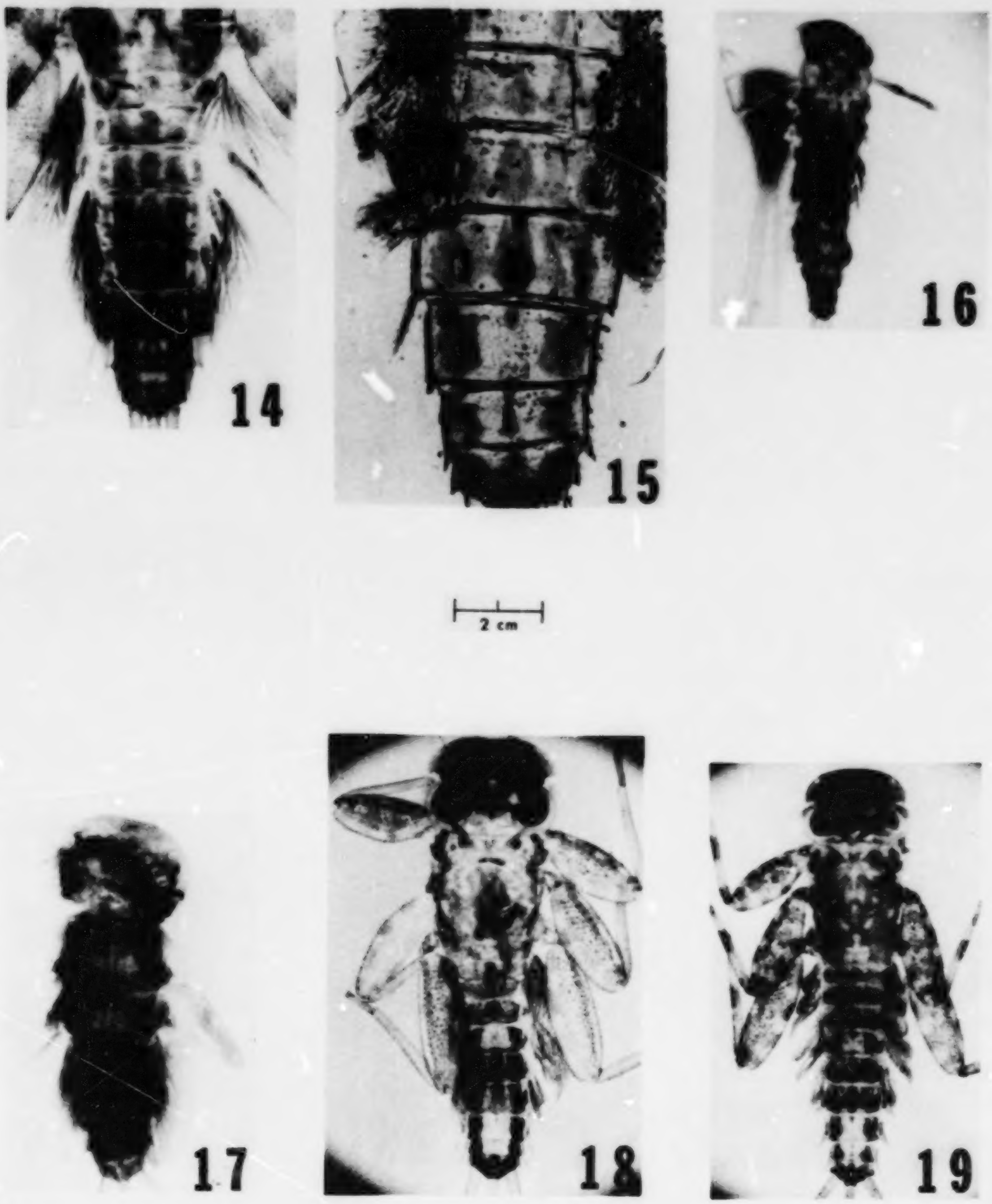
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PLATE II — FIGS. 14-19 DORSAL MACULATION OF NYMPHS

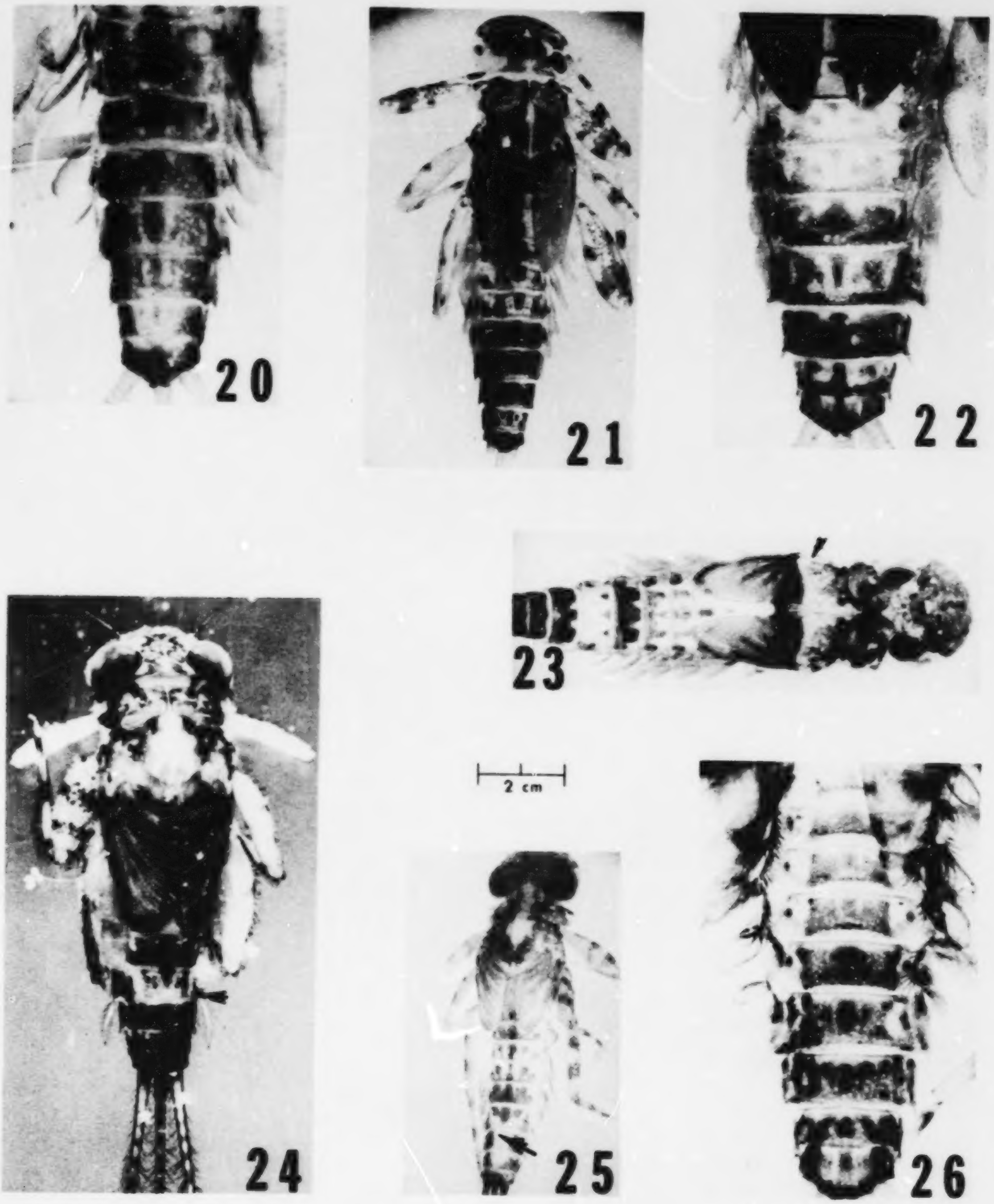
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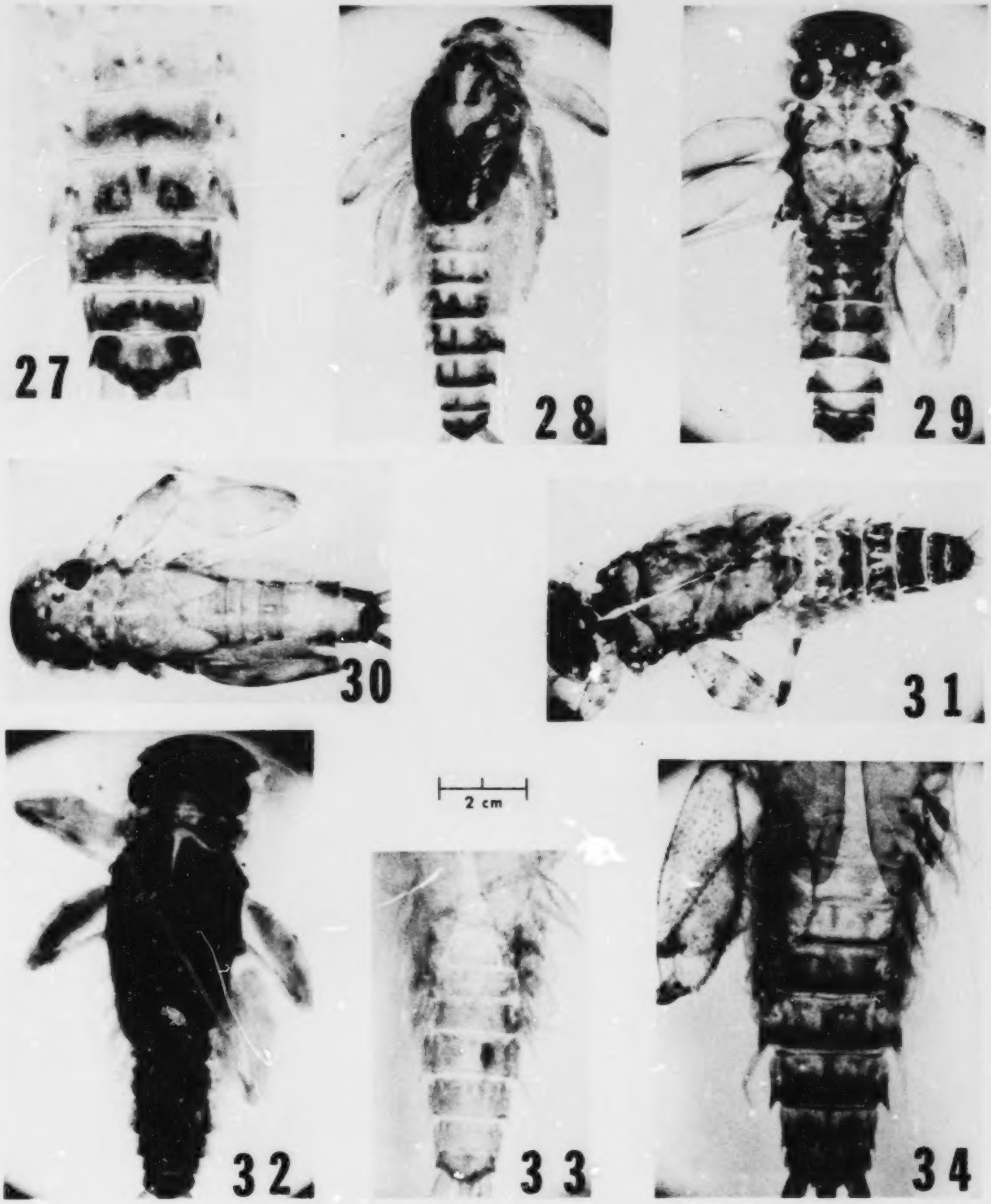
PLATE III — FIGS. 20-26 DORSAL MACULATION OF NYMPHS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31
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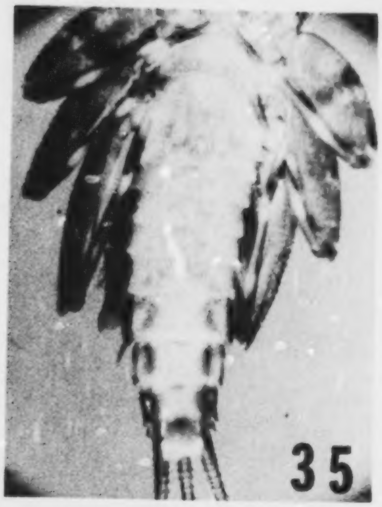
34

PLATE IV — FIGS. 27-34 DORSAL MACULATION OF NYMPHS



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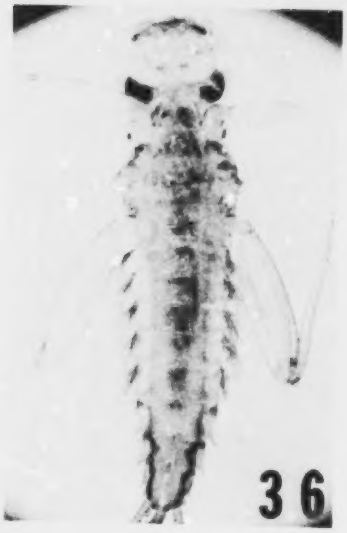

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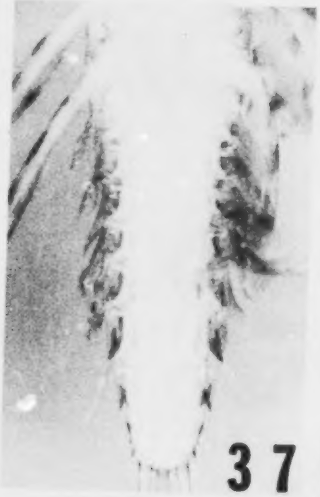

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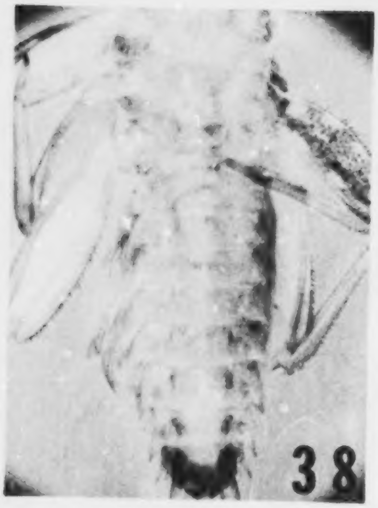

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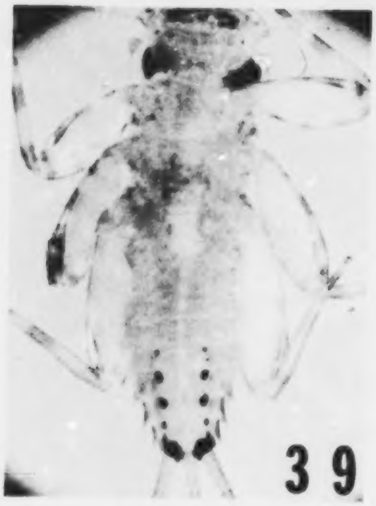

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PLATE V — FIGS. 35-39 VENTRAL MACULATION OF NYMPHS

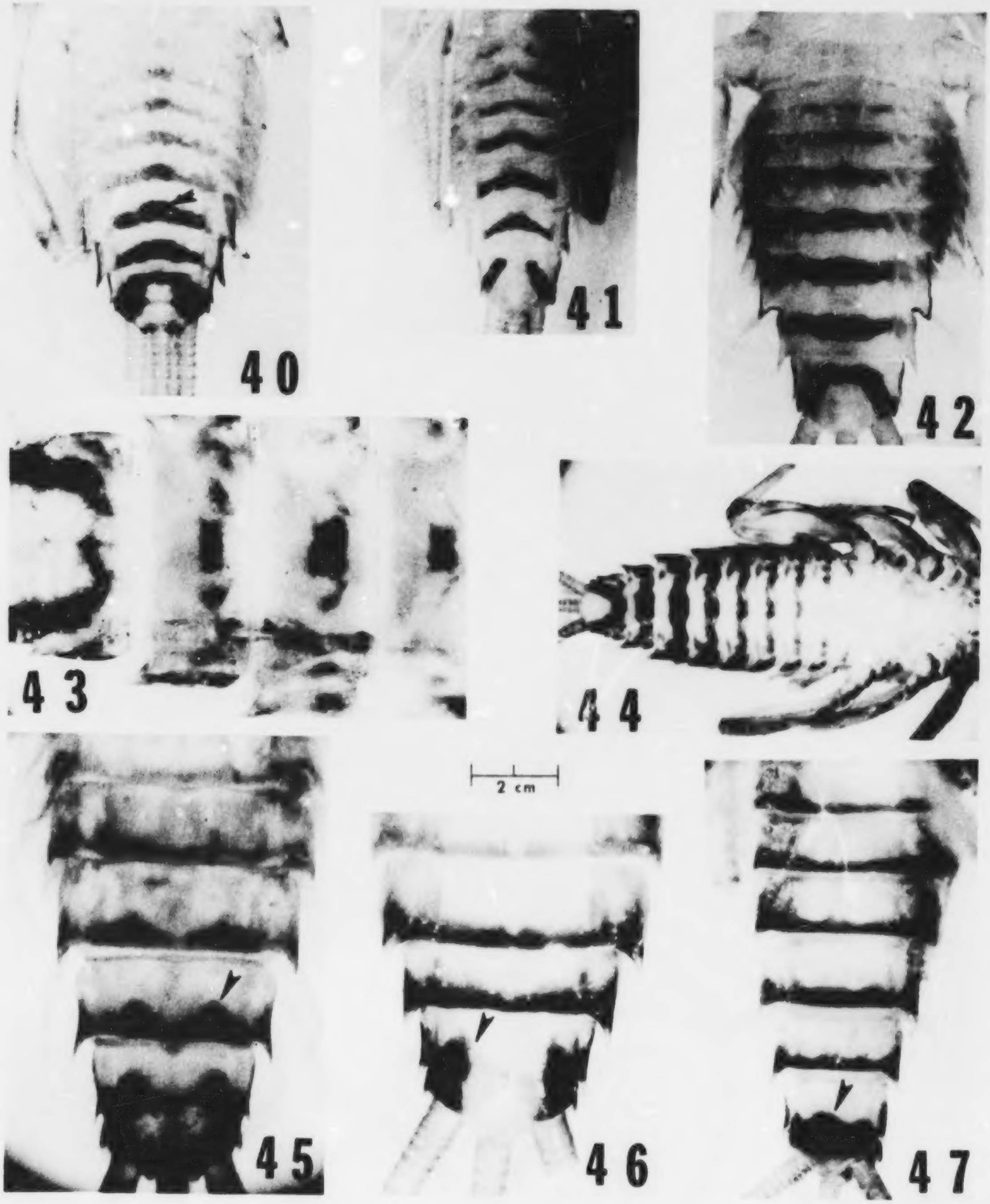
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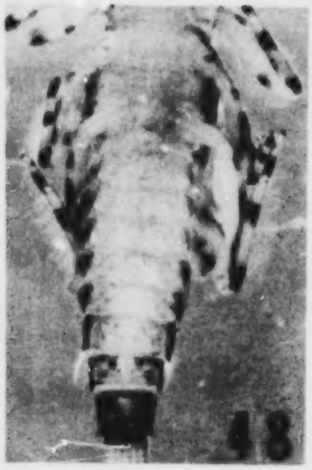
PLATE VI — FIGS. 40-47 VENTRAL MACULATION OF NYMPHS



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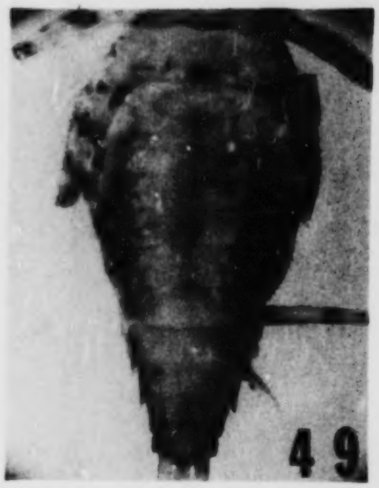

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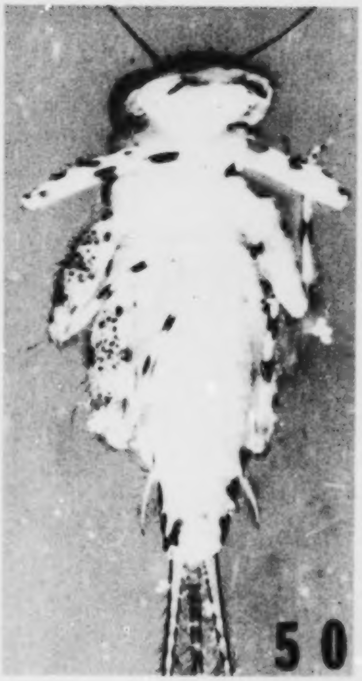

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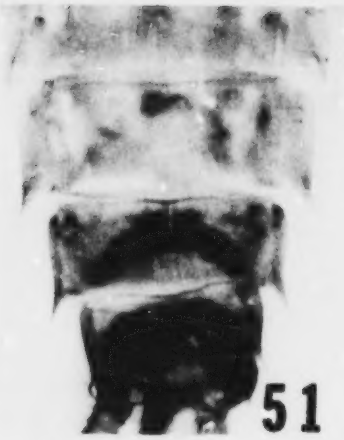

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2 cm

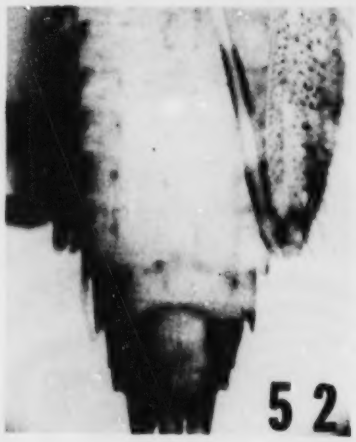

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PLATE VII — FIGS. 48-52 VENTRAL MACULATION OF NYMPHS

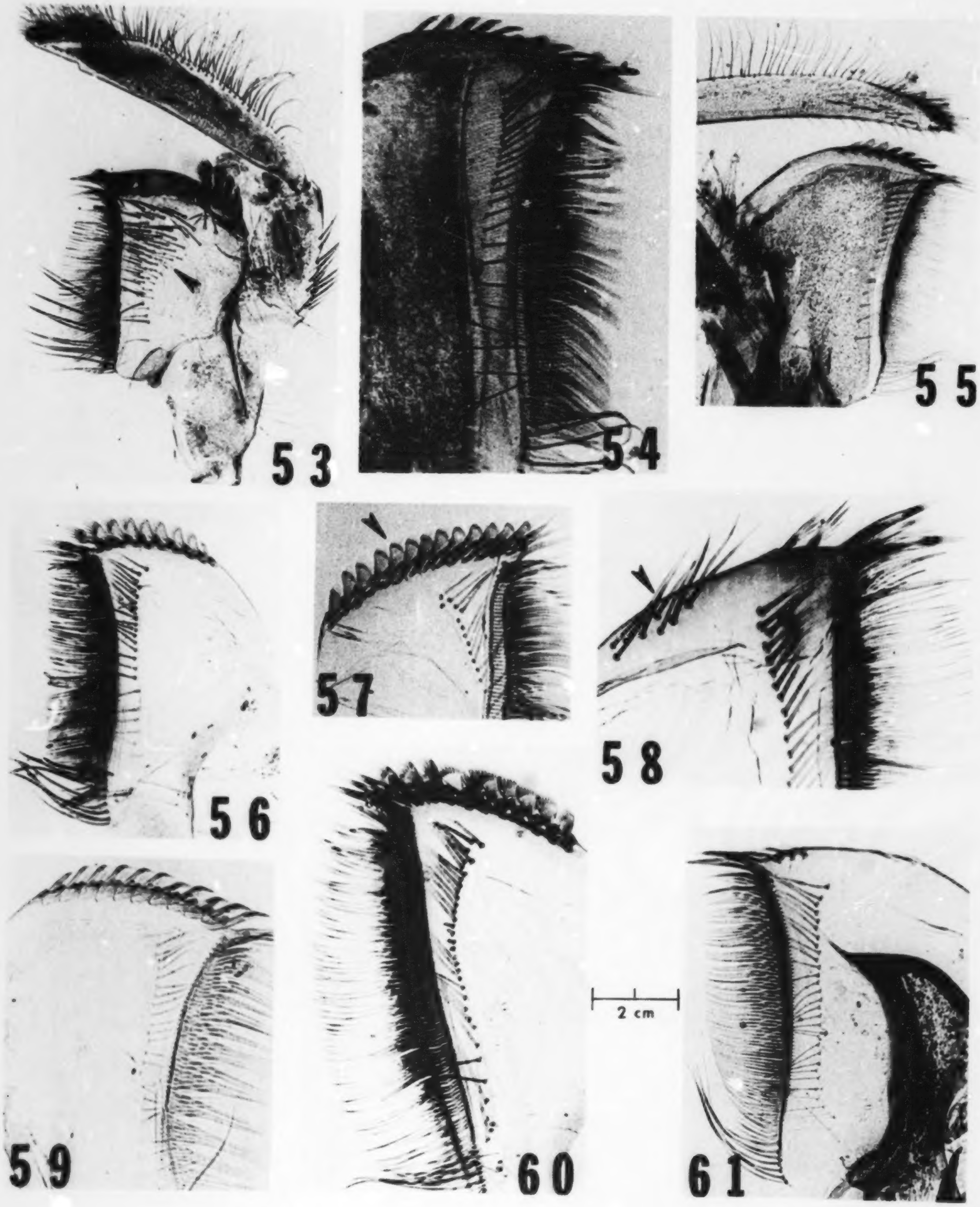
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PLATE VIII — FIGS. 53-61 MAXILLAE (Ventral view)

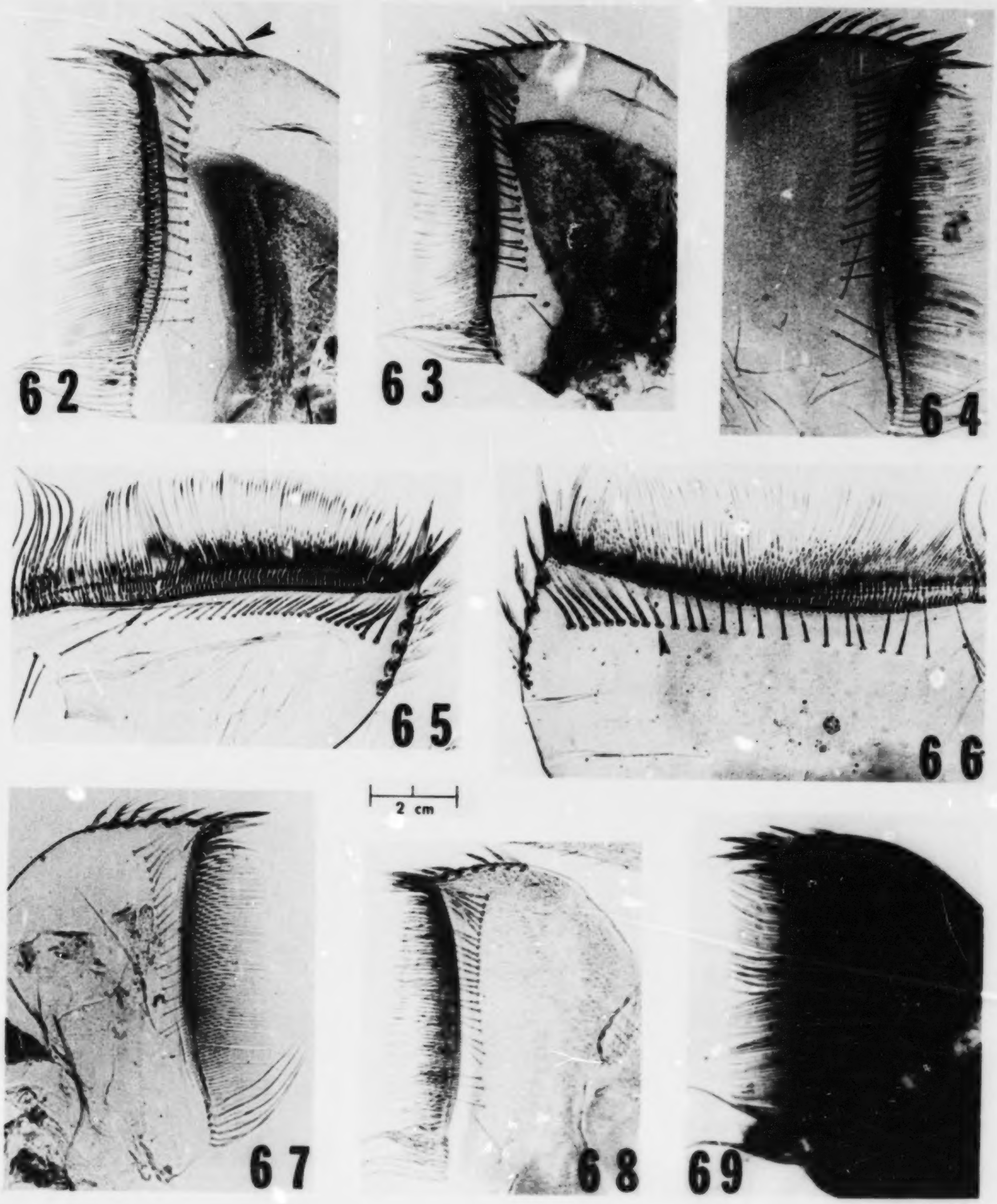
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PLATE IX — FIGS. 62-69 MAXILLAE (Ventral view)

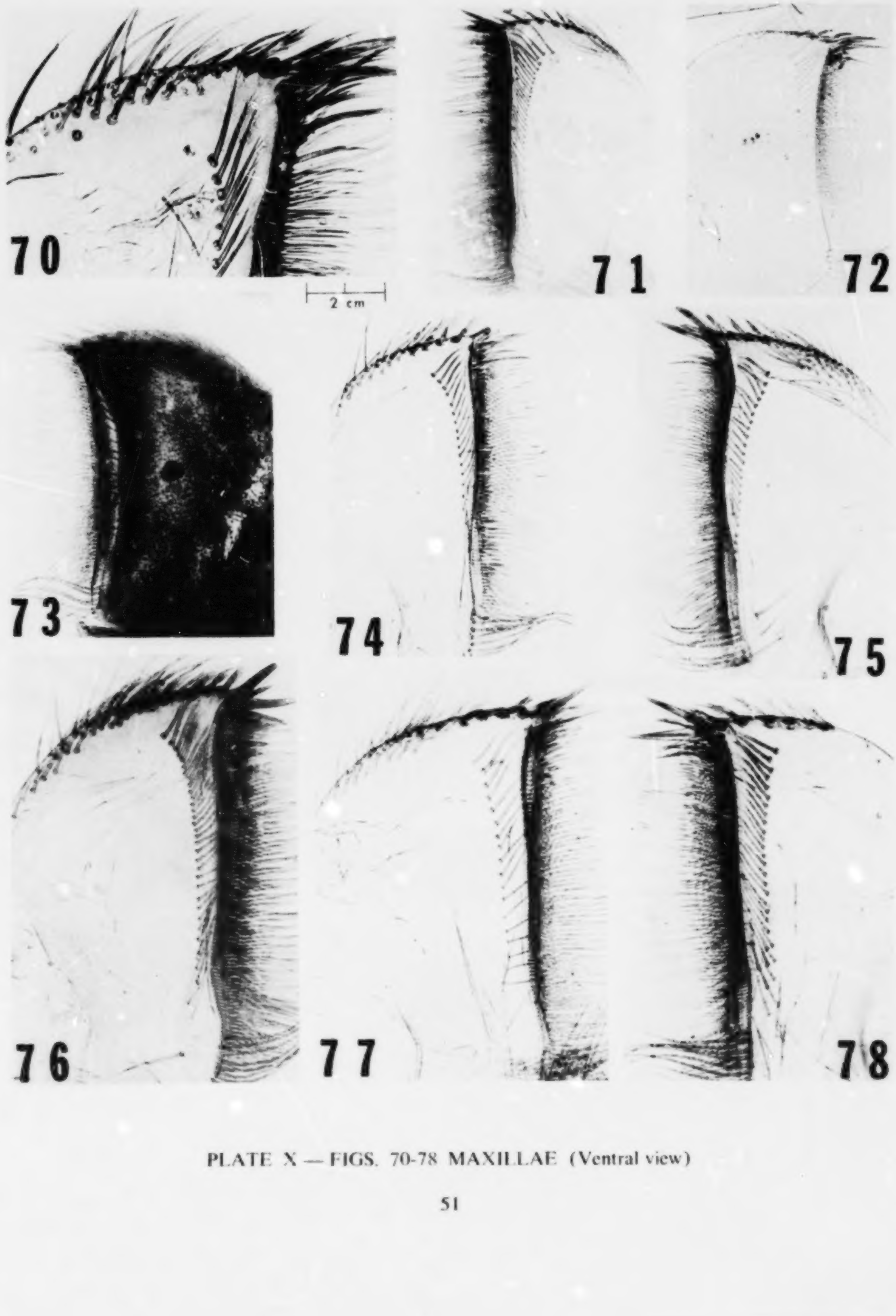
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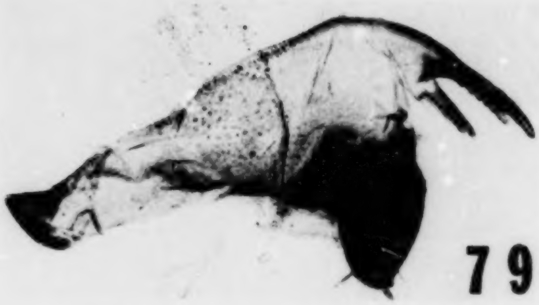
PLATE X — FIGS. 70-78 MAXILLAE (Ventral view)



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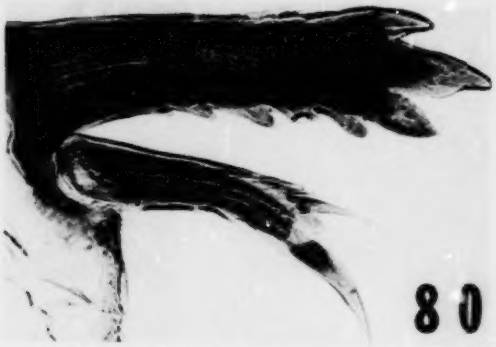

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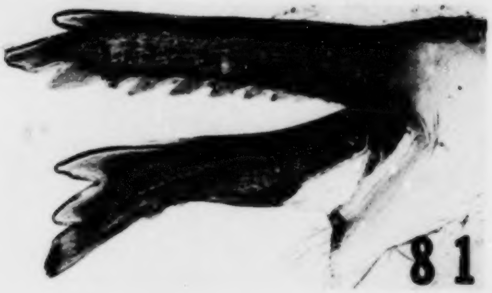

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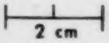
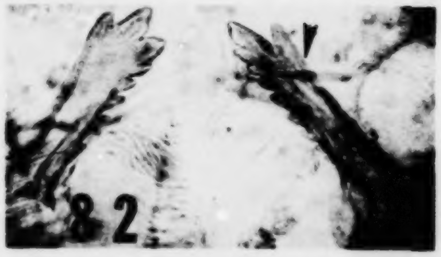
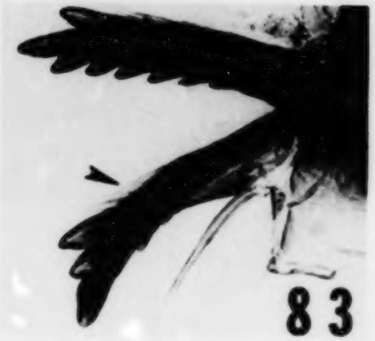
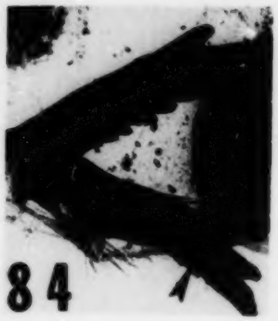




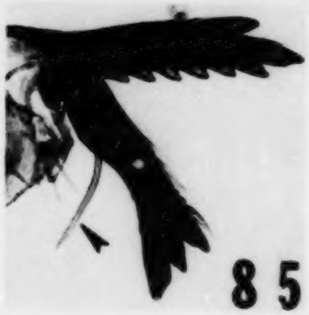
82



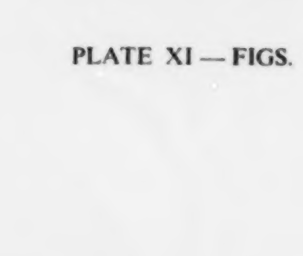
83



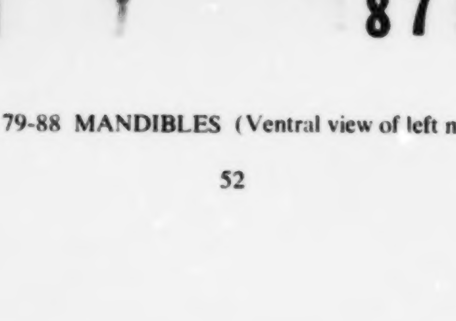
84



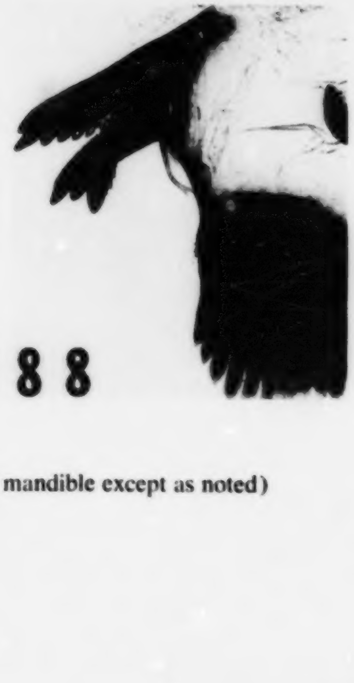
85



86



87



88

PLATE XI — FIGS. 79-88 MANDIBLES (Ventral view of left mandible except as noted)

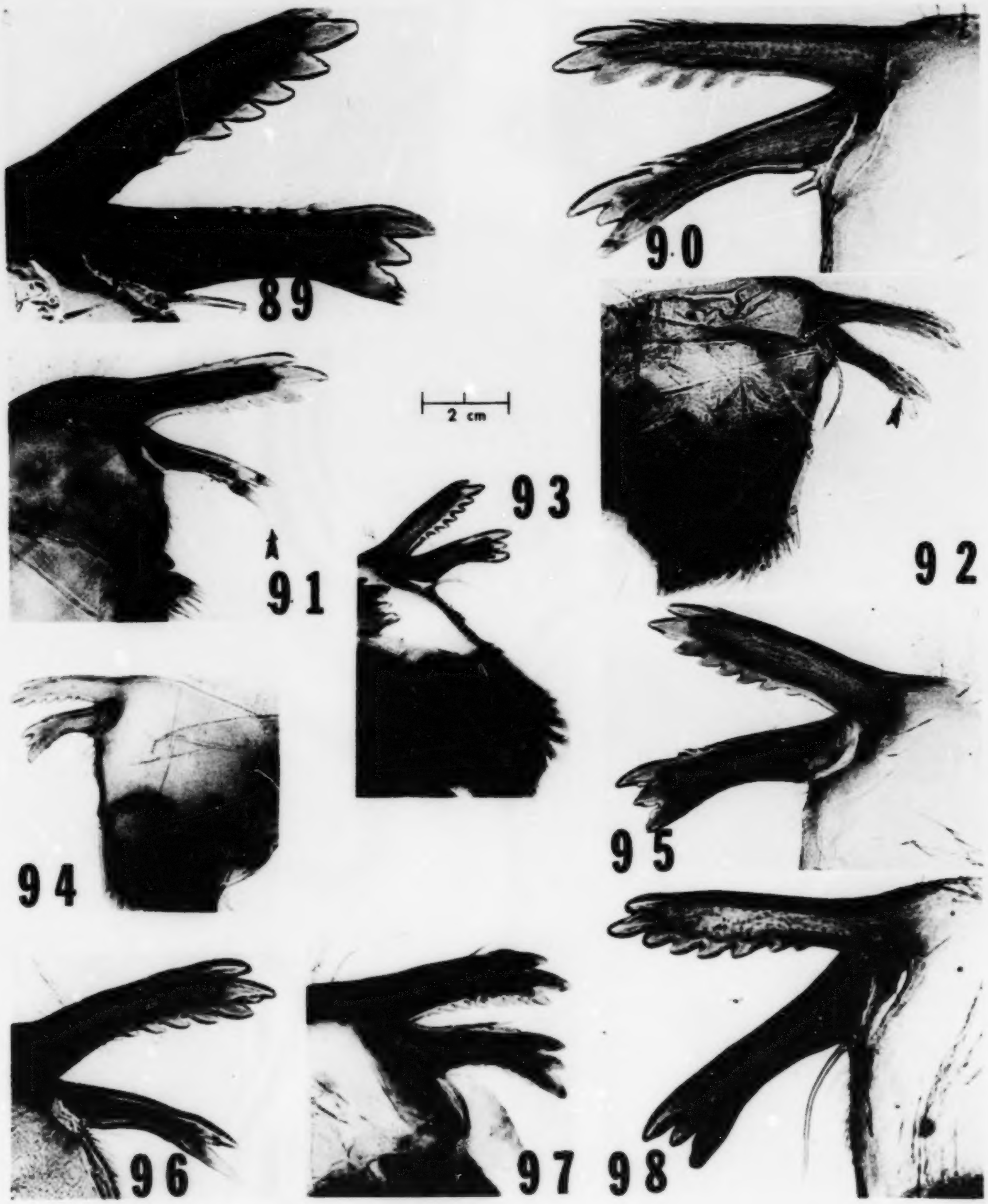
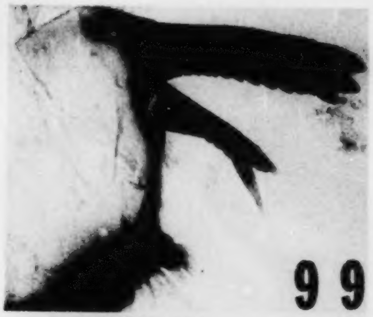
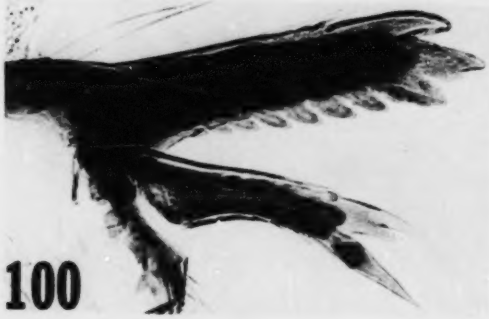
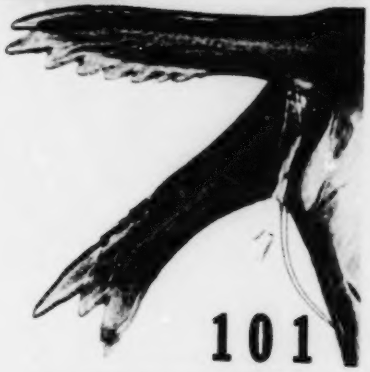
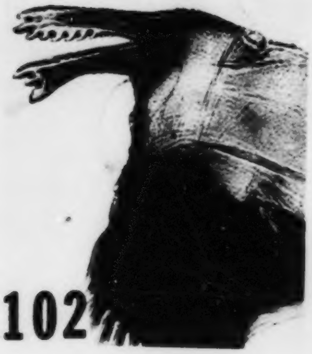

89
90
2 cm
91
93
92
94
95
96
97
98

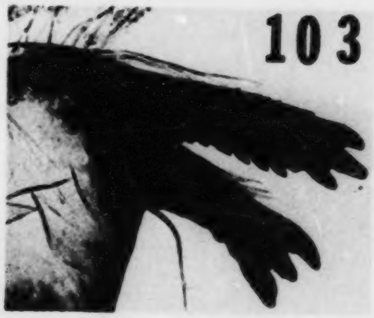
PLATE XII — FIGS. 89-98 MANDIBLES (Ventral view of left mandible except as noted)

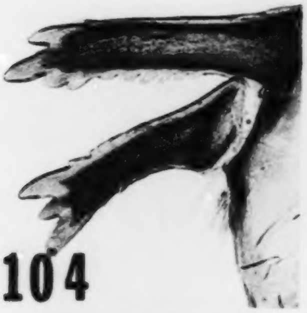

99

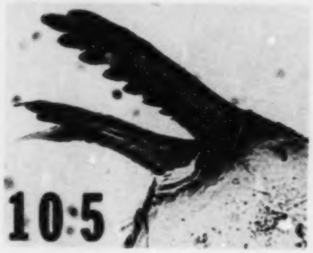

100

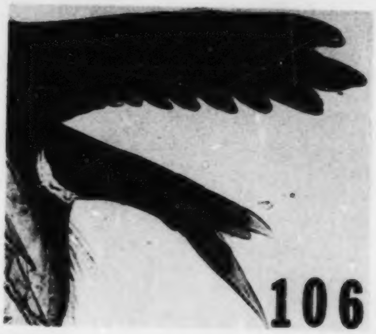

101

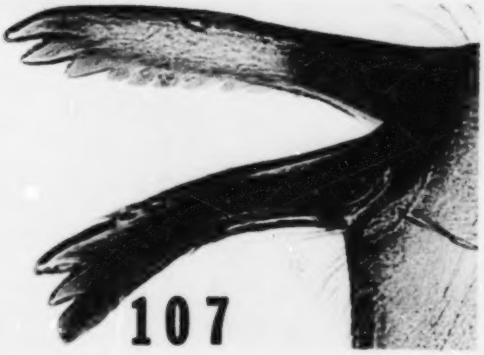

102

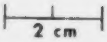

103


104


105


106


107



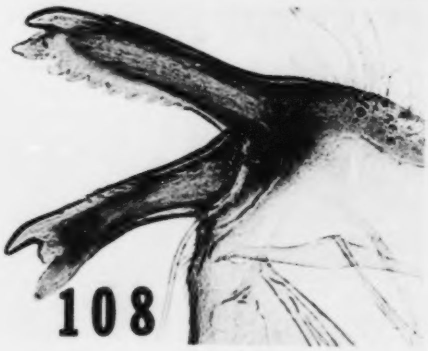

108

PLATE XIII — FIGS. 99-108 MANDIBLES (Ventral view of left mandible except as noted)

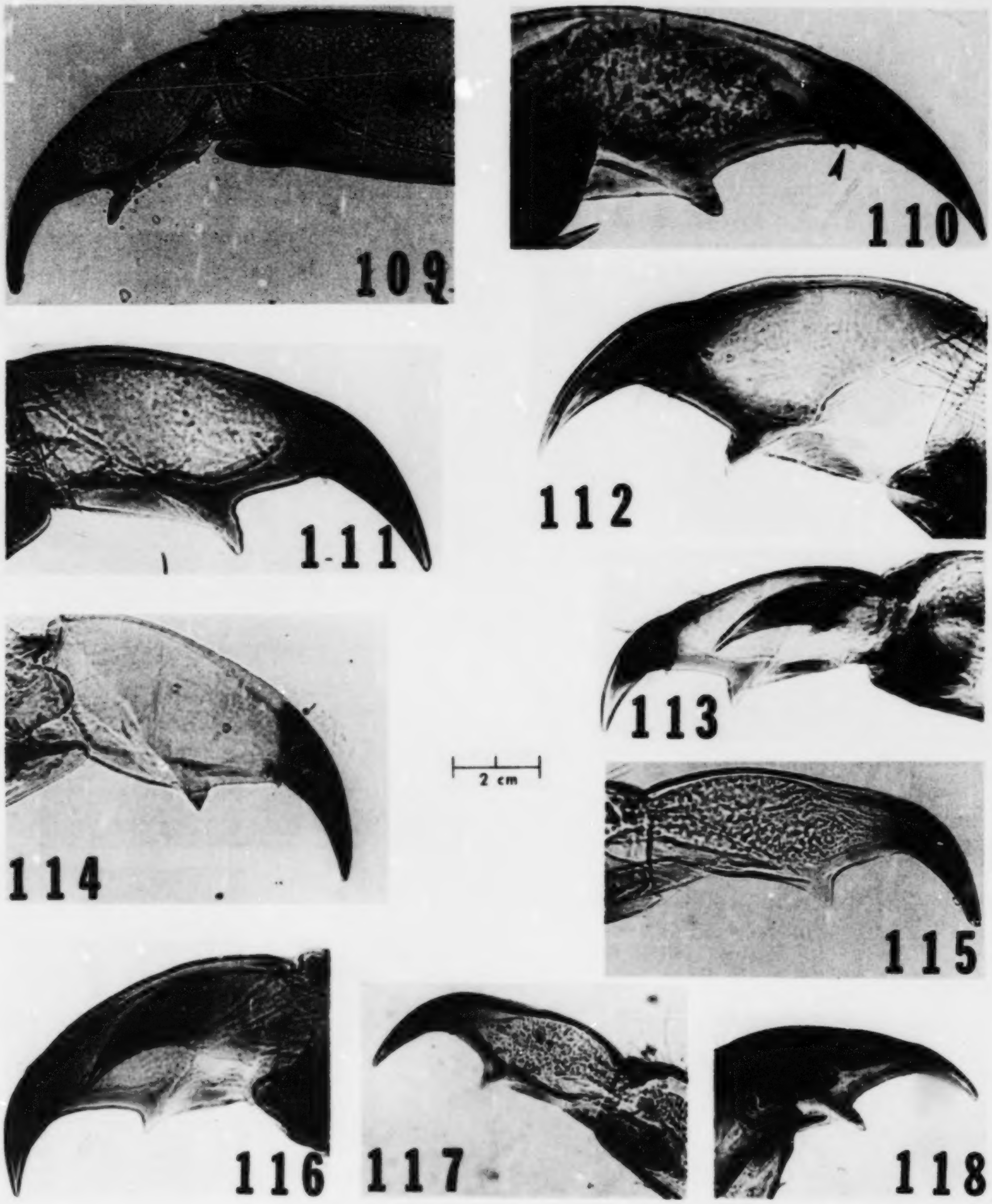
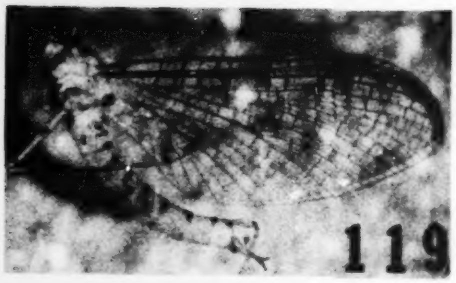
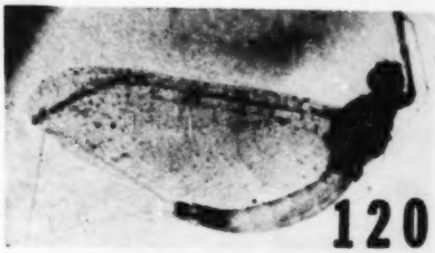
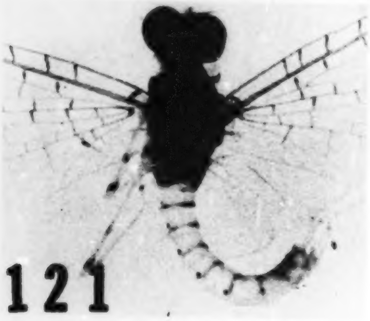
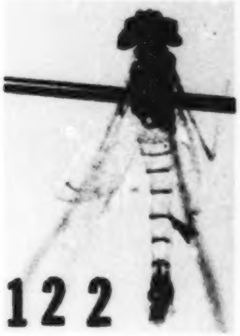

109
110
111
112
113
2 cm
114
115
116
117
118

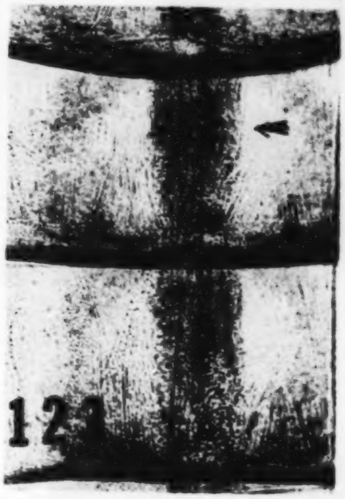
PLATE XIV — FIGS. 109-118 CLAWS OF THE NYMPHS

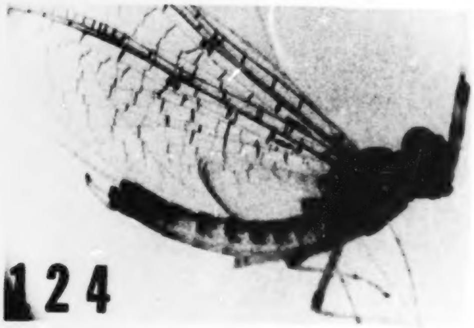

119

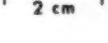

120

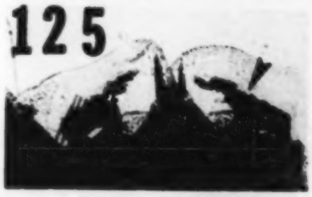

121

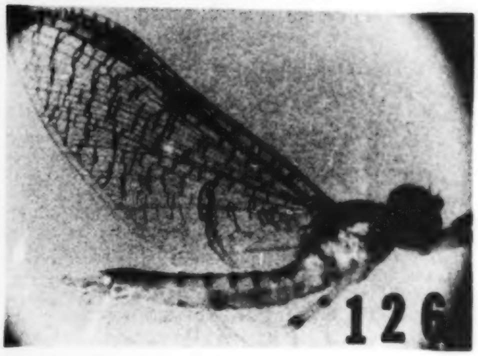

122

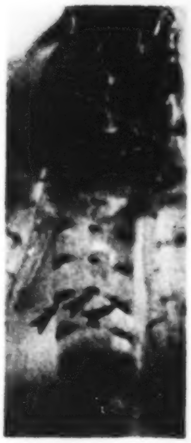

123


124




125


126



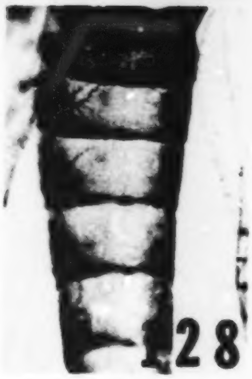
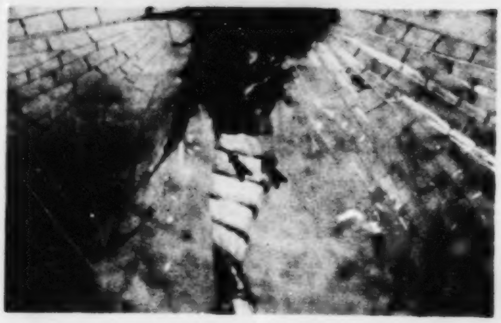
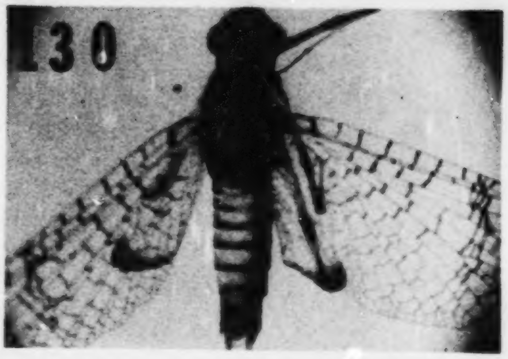
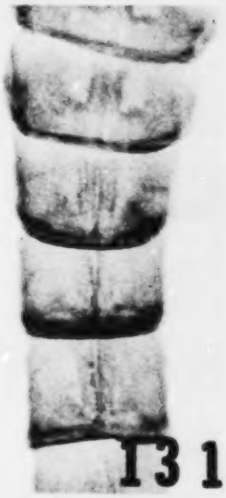

128

PLATE XV —FIGS. 119-128 MACULATION OF MALE IMAGOS

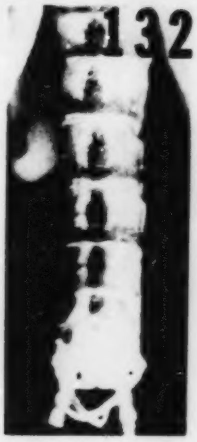




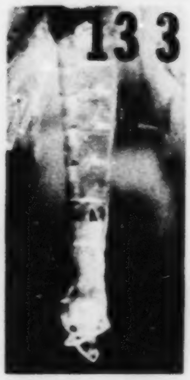
130



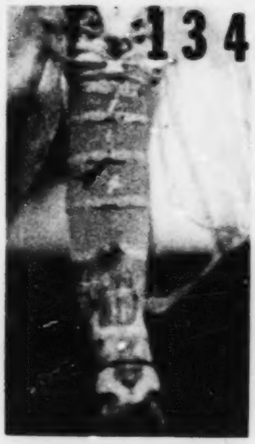
131



132

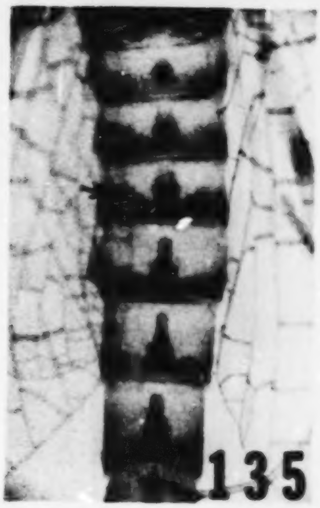


133

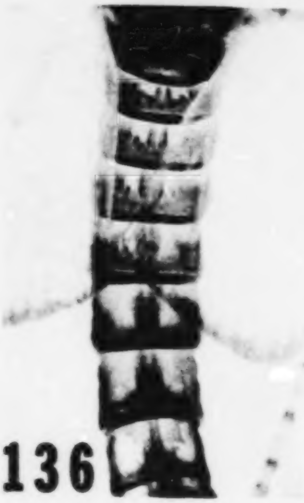


134

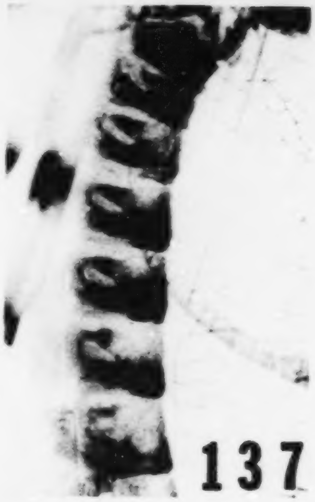
2 cm



135

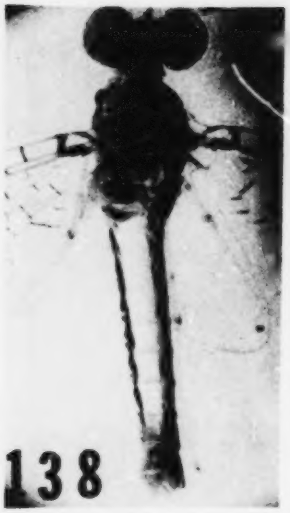


136

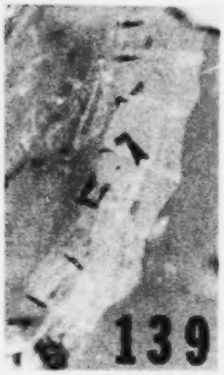


137

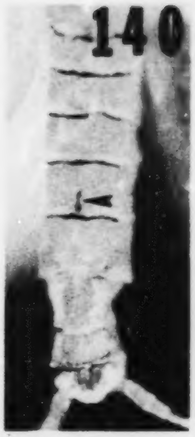
PLATE XVI — FIGS. 129-137 MACULATION OF IMAGOS (Males except as noted)



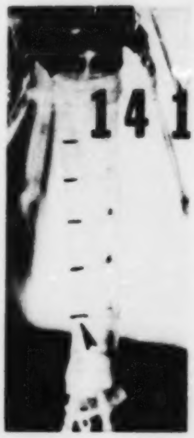
138



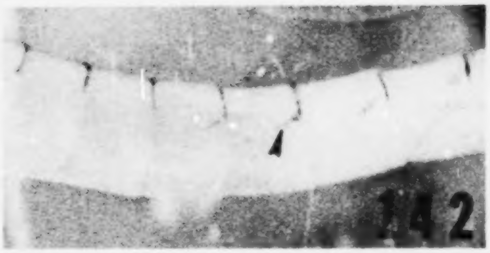
139



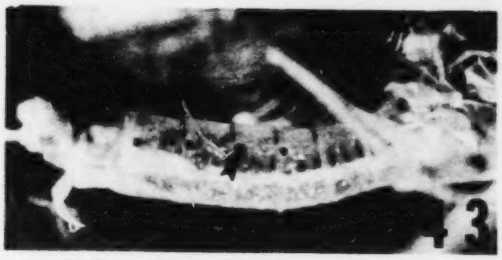
140



141

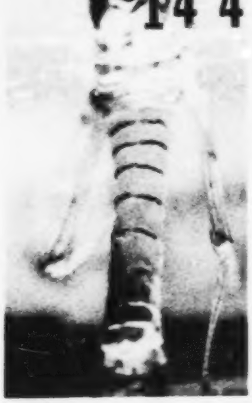


142

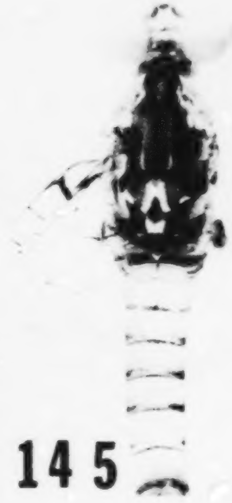


143

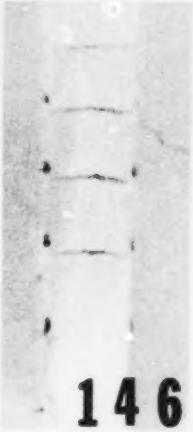
2 cm



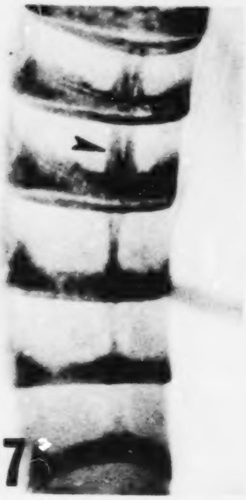
144



145

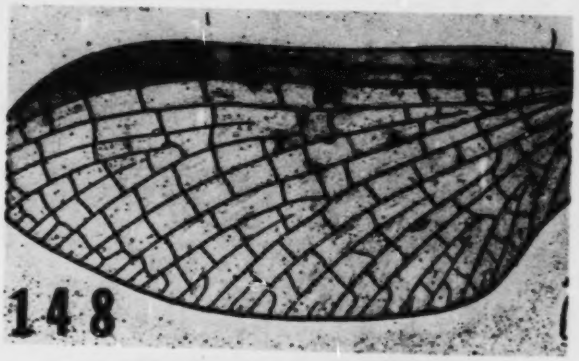


146

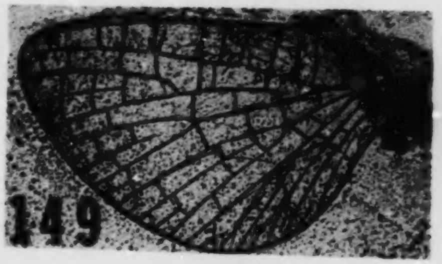


147

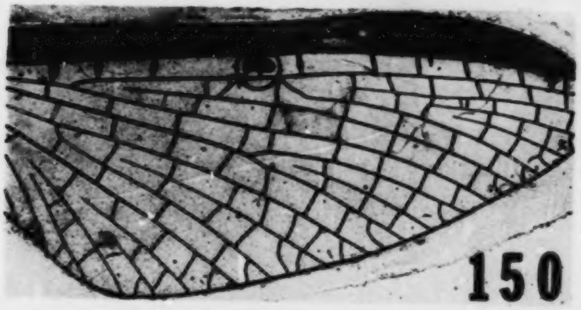
PLATE XVII — FIGS. 138-147 MACULATION OF IMAGOS (Males except as noted)



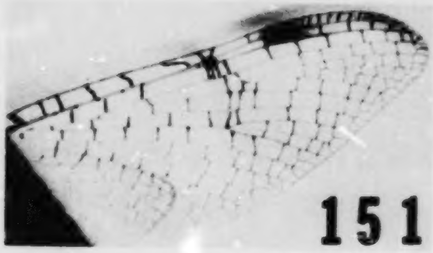
148



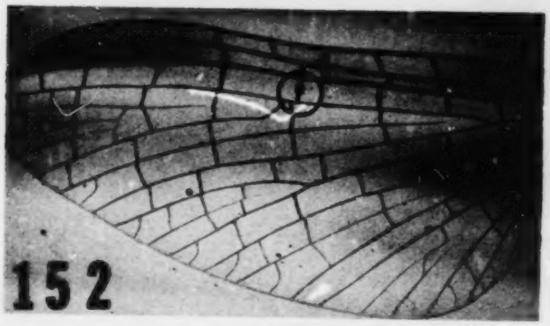
149



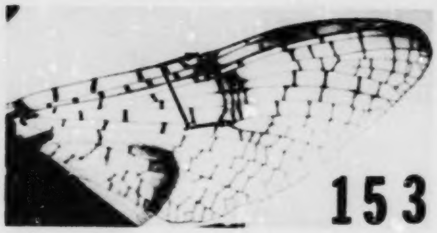
150



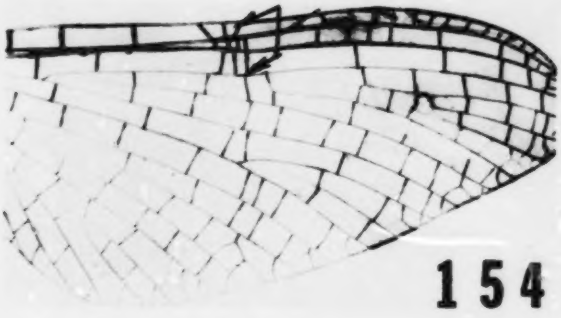
151



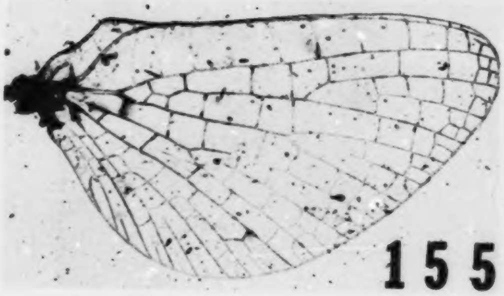
152



153

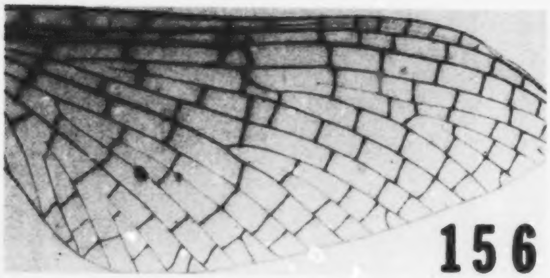


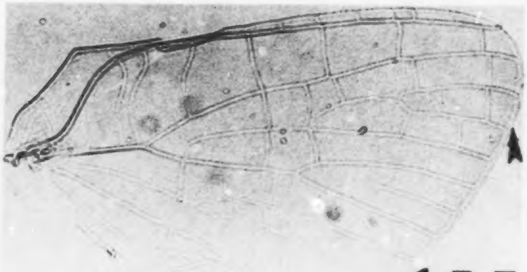
154

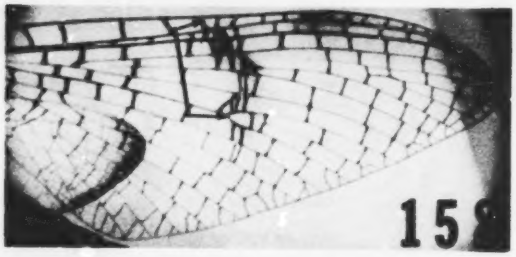


155

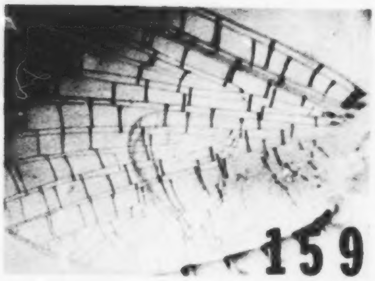
PLATE XVIII — FIGS. 148-155 WINGS

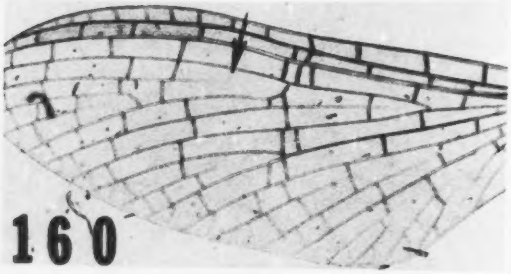

156

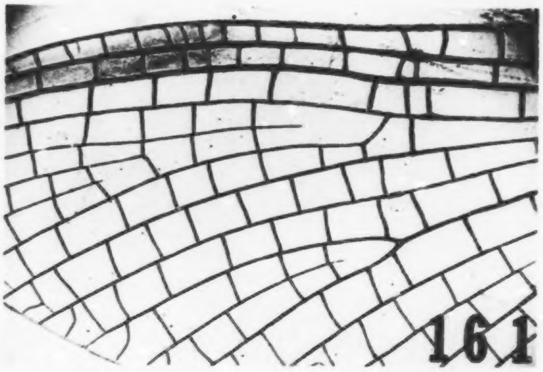

157

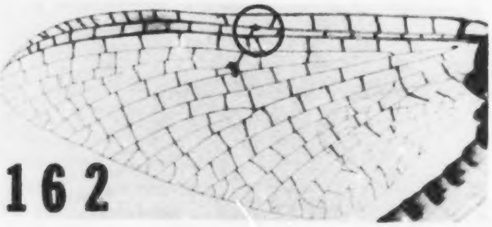

158

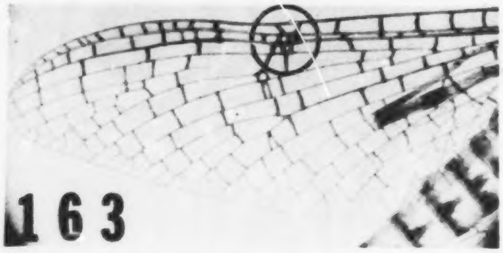
2 cm


159


160


161


162


163

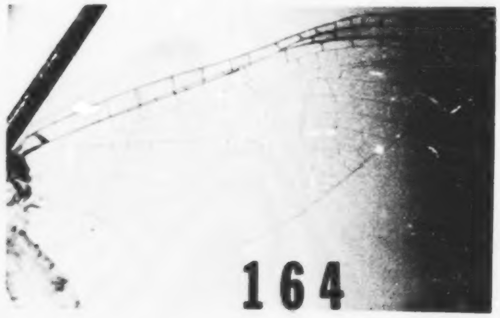
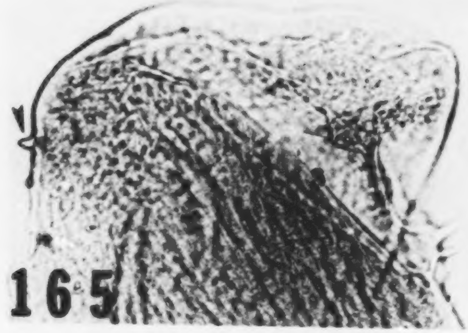
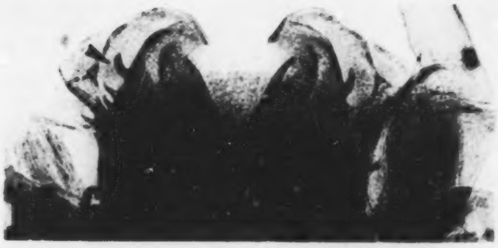
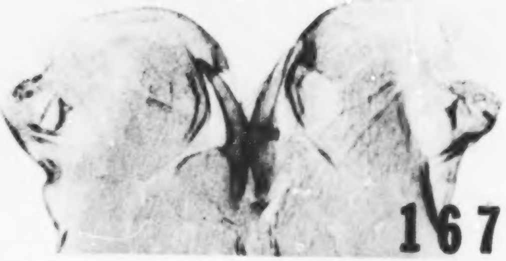
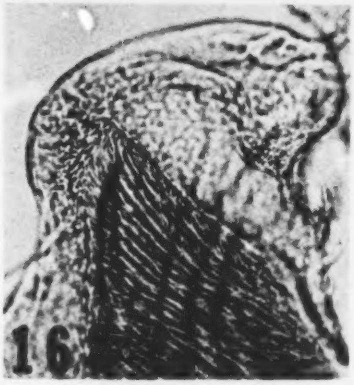

164

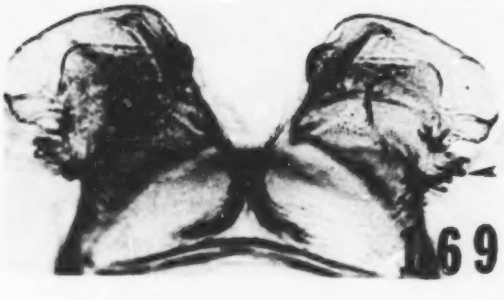
PLATE XIX — FIGS. 156-164 WINGS


165

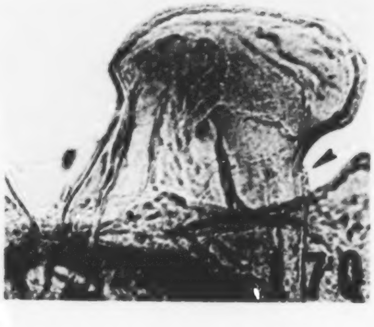


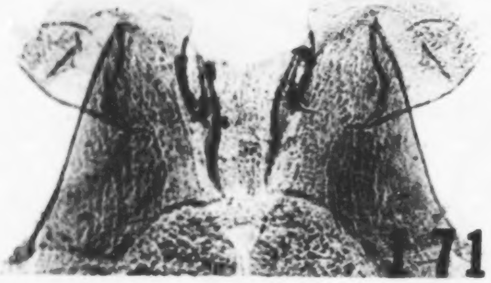

167


16


169

2 cm


170


171

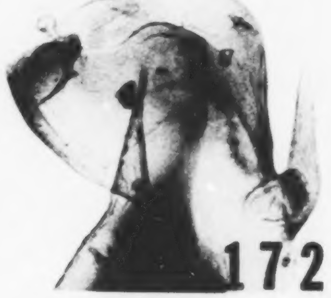
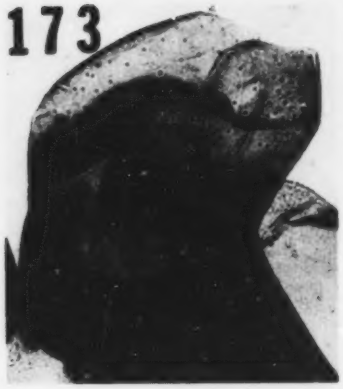
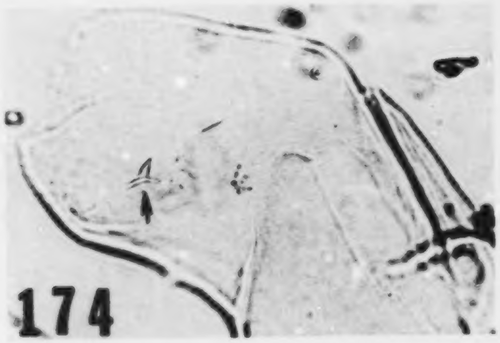

172

PLATE XX — FIGS. 165-172 MALE GENITALIA (Dorsal view)

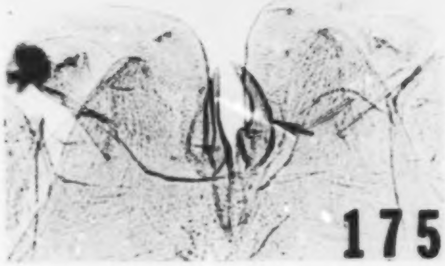
173



174

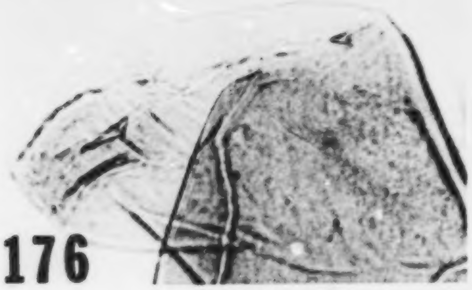


175

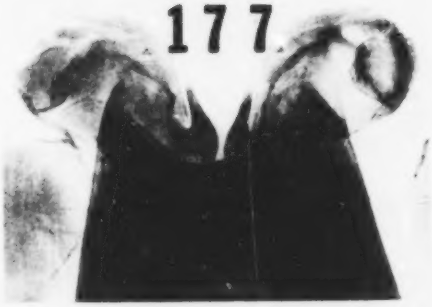


2 cm

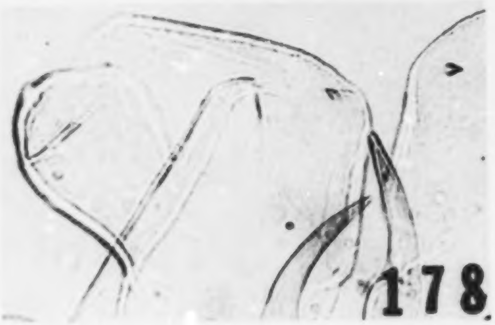
176



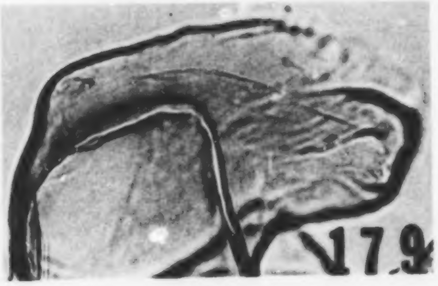
177



178



179



180

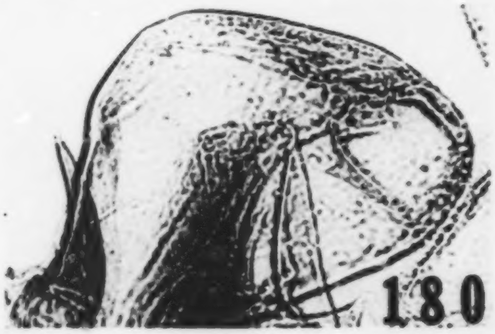


PLATE XXI — FIGS. 173-180 MALE GENITALIA (Dorsal view)

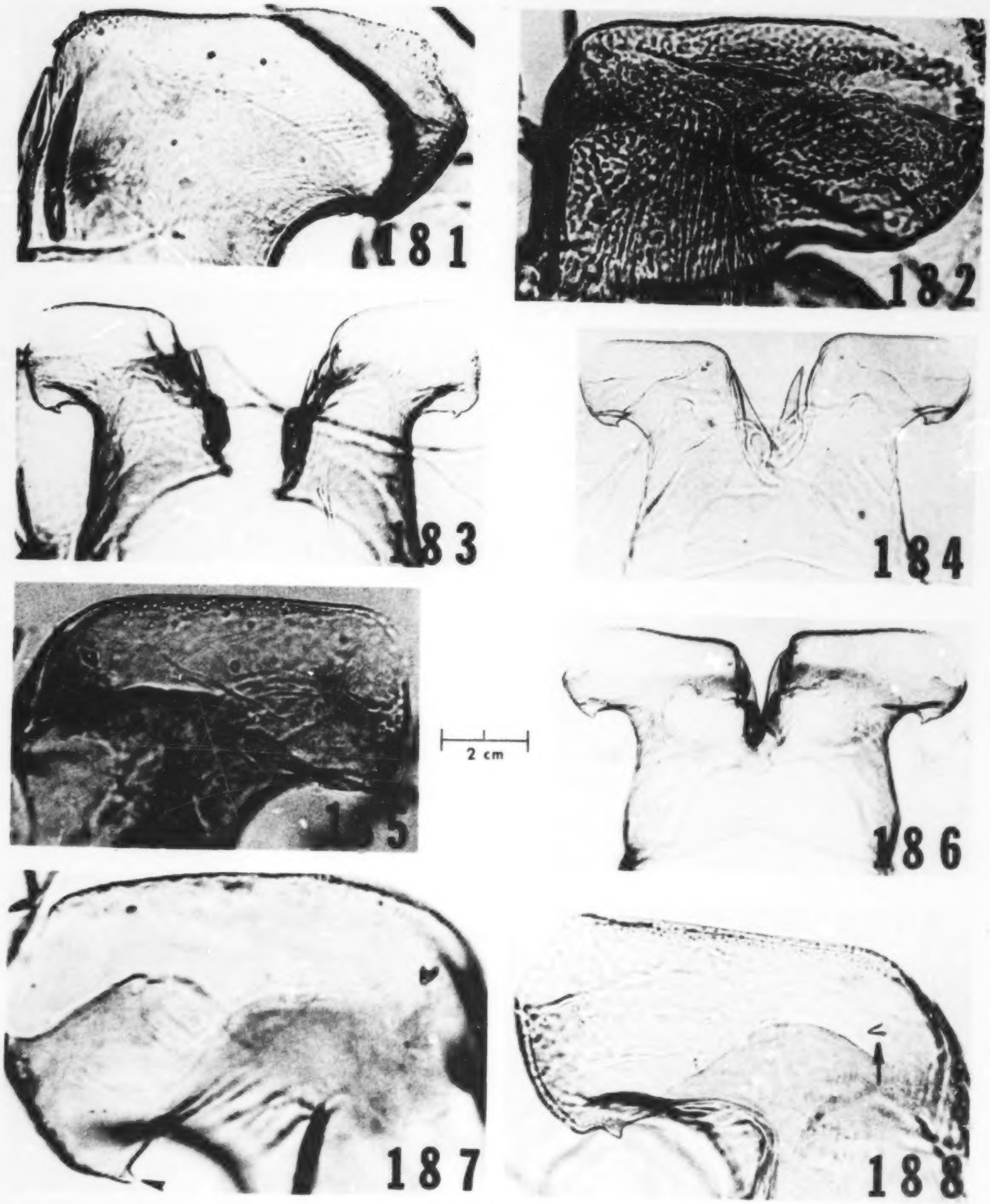

181
182
183
184
185
2 cm
186
187
188

PLATE XXII — FIGS. 181-188 MALE GENITALIA (Dorsal view)

APPENDIX B — TABLES

TABLE 3. SUMMARY OF COLLECTIONS EXAMINED

Collections	Nymphs	Subimagos		Imagos		Types examined[1]
		Males	Females	Males	Females	
				S. annexum		
Cornell	1			1		H
F. Myers				1		
INHS[2]				5		
Total	1			7		H
				S. ares		
P. Lewis	4					
J. Flannagan	1					
Fla. A&M	1					
INHS	3			7		H, P, T
U. of Wisc.					1	
Total	9			7	1	H, P, T
				S. bipunctatum		
P. Lewis					1	
J. Flannagan		2		2	1	
Fla. A&M				1		
CNC[3]				2		H
INHS	2				1	
U. of Wisc.	9			1		
Total	11	2		6	3	H
				S. i. canadense		
P. Lewis	10	3	2	1	8	
M. Anderson	1					
J. Flannagan		1		1		
INHS				6		P of *S. areion*
F. Myers				3		
Cornell	1	2	1	1	2	A, P of *S. ohioense*
Fla. A&M				1		
CNC				2	1	
Total	12	6	3	15	11	
				S. candidum		
INHS				3		
Cornell	1			3	1	H, A, P
F. Myers	1			1		
Total	2			7	1	H, A, P
				S. carlsoni		
Fla. A&M	1			2	2	H
Total	1			2	2	H
				S. carolina		
P. Lewis	1		1		2	
INHS				3		
Cornell		1	1	9	8	
Fla. A&M				2		
MCZ[4]				1		H
CNC	1			3	1	P
Total	2	1	2	18	11	H, P

TABLE 3. SUMMARY OF COLLECTIONS EXAMINED — Continued

Collections	Nymphs	Subimagos		Imagos		Types examined[1]
		Males	Females	Males	Females	
S. exiguum						
P. Lewis	5					
M. Anderson	1					
Cornell				3	2	H, P of *S. alabamae* and *S. exiguum*
CNC				1	1	P of *S. alabamae* and *S. exiguum*
INHS				6	1	
U. of Wisc.	1				1	
Total	7			10	5	H, P
S. femoratum						
P. Lewis	12		1	5	9	
U. of Minn.	1					
Cornell	2					
INHS	3		1	6	2	
Total	18		2	11	11	
S. floridense						
Fla. A&M				2	1	H
Total				2	1	H
S. i. frontale						
P. Lewis	10	1		5	2	
CNC				2		Hm
M. Anderson	3					
J. Flannagan	1	1				
INHS				3		
Cornell	3			8	2	H, P of *S. proximum* and *S. majus*
Fla. A&M	1					
MCZ	1			1		H
Total	19	2		19	4	H, Hm
S. fuscum						
P. Lewis	4			1		
F. Myers	1					
MCZ				1		P of *S. rivulicolum*
CNC				1		H of *S. rivulicolum* and *S. fuscum*
INHS	1			3	1	
U. of Wisc.				3	1	
Total	6			9	2	H
S. gildersleevei						
P. Lewis	1				4	
INHS				1		
Cornell	8	1		3	3	P
CNC	2			1	1	P
Total	11	1		5	8	P
S. i. heterotarsale						
P. Lewis	4	8	7	1	1	
M. Anderson	1					
INHS	4			2		
Cornell	2					
MCZ				2		P
CNC				8	3	H, A, P
Total	11	8	7	13	4	H, A, P

TABLE 3. SUMMARY OF COLLECTIONS EXAMINED — Continued

Collections	Nymphs	Subimagos		Imagos		Types examined[1]
		Males	Females	Males	Females	
			S. integrum			
P. Lewis	34	5	2	13	24	
M. Anderson	5					
U. of Minn.				2	2	P of *S. wabasha*
Cornell				2		H, P of *S. bellum*
Fla. A&M				14	1	
CNC				1		P
INHS	1			4		H, P of *S. wabasha* and *S. integrum*
Total	40	5	2	36	27	H, P
			S. i. interpunctatum			
P. Lewis	24	10	4	11	12	
M. Anderson	19					
J. Flannagan	1					
INHS	32			22		
Cornell	1			4		H, P of *S. conjunctum* and *S. affine*
F. Myers	1			3	1	
Fla. A&M	1			2		
U. of Wisc.	1			1		
MCZ	1			1		
CNC				3		
Total	81	10	4	47	13	
			S. ithaca			
P. Lewis	2					
Cornell	9	4	4	8	6	P
CNC				2	1	H, T
INHS	2					
Total	13	4	4	10	7	H, P, T
			S. lepton			
P. Lewis			1			
INHS				5		P
Total			1	5		P
			S. luteum			
P. Lewis	3					
CNC				2	1	H, Hm
INHS				1		
U. of Wisc.	2			1		
Total	5			4	1	H, Hm
			S. mediopunctatum			
P. Lewis	3					
J. Flannagan		1				
Cornell					1	
CNC				1		H
U. of Wisc.	3			2	1	
Total	6	1		3	2	H
			S. minnetonka			
P. Lewis	5	1	7	18	15	
INHS				1		
U. of Wisc.				1		
Total	5	1	7	20	15	
			S. modestum			
MCZ				2		H
Total				2		H

TABLE 3. SUMMARY OF COLLECTIONS EXAMINED — Continued

Collections	Nymphs	Subimagos		Imagos		Types examined[1]
		Males	Females	Males	Females	
S. nepotellum						
P. Lewis	11				5	
M. Anderson	1					
F. Myers		1	2	7	1	
Fla. A&M	1					
MCZ				1		P
CNC				2		H
INHS	3			2	1	
Total	16	1	2	12	7	H, P
S. pallidum						
P. Lewis	1					
Cornell	1			2		H, P
J. Richardson				1		
Total	2			3		H, P
S. placitum						
CNC				2		H
Total				2		H
S. pudicum						
P. Lewis	2					
M. Anderson	1					
F. Myers	1					
Fla. A&M				1		
MCZ				1		H, P
CNC				1		
INHS	3			2	2	
J. Richardson				3	1	
Total	7			8	3	H, P
S. pulchellum						
P. Lewis	36	2	3	8	13	
M. Anderson	7					
F. Myers	1				1	
Fla. A&M	1			1		
MCZ				2		H, P
CNC				2		Hm
INHS	1				1	
J. Richardson				2		
Total	46	2	3	15	15	H, Hm, P
S. quinquespinum						
P. Lewis	8	2	1	10	19	H, A, P depositeu in INHS Museum
U. of Wisc	1			1		
Total	9	2	1	11	19	H, A, P
S. rubromaculatum						
P. Lewis	19			1	4	
F. Myers	1					
CNC				2	2	H, A
INHS	1			8	1	
J. Richardson				4		
Total	21			15	7	H, A
S. rubrum						
P. Lewis	3					
J. Flannagan	3					
Cornell				2	1	H, P of *S. varium*
MCZ				1		
CNC	1			6	2	H, P
INHS				1		
U. of Wisc.	3			3		
Total	10			13	3	H, P

TABLE 3. SUMMARY OF COLLECTIONS EXAMINED — Continued

Collections	Nymphs	Subimagos Males	Subimagos Females	Imagos Males	Imagos Females	Types examined[1]
			S. smithae			
P. Lewis	1	1		1		
Cornell				4		H, P
Fla. A&M	1	2	1	2	1	
INHS				1	1	
J. Richardson				1	1	
Total	2	3	1	9	3	H, P
			S. terminatum			
P. Lewis	27	2	2	10	17	
M. Anderson	1					
F. Myers	1					
Fla. A&M				1		
MCZ				2	1	H, P
CNC	2			2		Hm
INHS				4		
U. of Wisc.	6					
Total	37	2	2	19	18	H, Hm, P
			S. tripunctatum			
P. Lewis	38	3	6	25	23	
M. Anderson	13					
U. of Minn.	5	2	5	8	5	
Cornell	1			2	2	H, P of *S. birdi* and *S. scitulum*
F. Myers	2		1	2	2	
Fla. A&M	2			5	2	
MCZ				2		H, P
CNC					1	
INHS	2		1	5	2	
Total	63	5	13	49	37	H, P
			S. vicarium			
P. Lewis	17			1		
J. Flannagan	2			1		
M. Anderson	1					
U. of Minn.	3					
Cornell					1	
CNC				1		
INHS	1			2		
Total	24			5	1	
Grand Total	497	56	54	419	242	

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[1] H = Holotype, P = Paratype, T = Topotype, Hm = Homotype, A = Allotype

[2] Illinois Natural History Survey Collection, Urbana

[3] Canadian National Collection, Entomological Research Institute, Ottawa, Ontario

[4] Museum of Comparative Zoology, Cambridge, Mass.

TABLE 4. *STENONEMA* COLLECTING SITES IN THE OHIO RIVER BASIN

(Site numbers are keyed on Figure 1, a map of the region.)

Site no.	Date	Stream	Location	Notes[1]	Species collected
1	4-29-68	Little Miami River	1 mile east of Newtown, OH	H	*tripunctatum, pulchellum, interpunctatum, quinquespinum*
2	*5-25-66	Salamonie River	Pennville, IN	B	*femoratum, scitulum, interpunctatum*
3	8-25-70 8- 7-68 10- 2-68	Ohio River	Cincinnati, OH	B B B	*tripunctatum, integrum, metriotes, terminatum*
4	4-21-69	Creek along State Rt. 46	East of St. Leon, IN	H	*femoratum, scitulum*
5	5-28-69	Shayler Run Creek	South of Milford, OH	H	*tripunctatum, scitulum, interpunctatum, femoratum*
6	6- 4-69	Lake White Inlet Creek	South of Waverly, OH	H	*tripunctatum, interpunctatum*
7	8- 8-69	Boiling Spring Creek	Munfordville, KY	P.H. 8.0 H TDS 250	*scitulum, femoratum, tripunctatum*
8	9-13-68 5- 5-70	Scioto River	Portsmouth, OH	B G	*terminatum, pulchellum?, tripunctatum*
9	10-20-69 5-27-70	Little Miami River	Loveland, OH	S S	*pulchellum, integrum, quinquespinum, interpunctatum, tripunctatum*
10	10- 3-68 6- 6-67 7-18-68 8-13-69 10-10-69	Little Miami River	Cincinnati, OH	B B B B B	*pulchellum, quinquespinum, interpunctatum, terminatum, tripunctatum, integrum*
11	*6- 6-66	Eel River	Hoovers, IN	B	*interpunctatum, exiguum?*
12	*6- 2-66	Wabash River	Linngrove, IN	B	*interpunctatum*
13	*6- 2-66	Wabash River	Wabash, IN	B	*interpunctatum*
14	1-16-69 2-18-69	Little Miami River	Batavia, OH	H H	*pulchellum*
15	8-24-66 *5-15-63 11- 9-66 7-15-66 *9- 5-67	Wabash River	New Harmony, IN	B B B B B	*integrum, ares*
16	7- 6-66 11-17-66	Ohio River	Louisville, KY	B B	*integrum, interpunctatum*
17	7-23-68 9-23-66 9- 5-67 8-26-69	Ohio River	Sayler Park, OH	B B B B	*integrum, scitulum, terminatum*
18	*10-22-65	Flatrock River	Columbus, IN	B	*interpunctatum*
19	6-23-69	Mohican River	Danville, OH	Enriched waters H	*interpunctatum* (ssp. *heterotarsale*)
20	7-24-69	South Branch Oswego Creek	Coneville, PA	H	*interpunctatum* (ssp. *canadense*), *fuscum, ithaca?*
21	8- 6-69	Little Wabash River	Crossville, IL	N	*interpunctatum*
22	7-23-68	Great Miami River	Lawrenceburg, IN	B	*terminatum, tripunctatum, integrum*
23	4-21-69 8- 4-69	Flatrock River	St. Omer, IN	PH 7.55 H TDS 330 H	*ares?, interpunctatum, nepotellum, pulchellum*

TABLE 4. *STENONEMA* COLLECTING SITES IN THE OHIO RIVER BASIN — Continued

(Site numbers are keyed on Figure 1, a map of the region.)

Site no.	Date	Stream	Location	Notes[1]	Species collected
24	4-21-69	Flatrock River	St. Paul, IN	H	*ares*
25	8-26-69 8-22-70 7-23-68	Ohio River	Anderson Ferry, OH	M B B	*metriotes, integrum, interpunctatum, scitulum, terminatum*
26	8- 4-69	Sugar Creek	London, IN	H	*nepotellum, pulchellum?, ares*
27	8-15-69	Kentucky River	Wilmore, KY	PH 7.5 H TDS 250	*femoratum, interpunctatum*
28	8-15-69	Creek by U.S. 127	Northeast of Liberty, KY	PH 7.5 H TDS 330	*scitulum, tripunctatum*
29	8-15-69	Paint Lick Creek	Kirksville, KY	PH 8.0 H	*tripunctatum?, femoratum, scitulum*
30	8- 5-69	Moots Creek	East of Ash Grove, IN	N	*terminatum?*
31	7-14-69 8-25-69 10-14-69 7-30-68	Ohio River	Madison, IN	B M M B	*terminatum?, exiguum?, integrum, interpunctatum, tripunctatum?, pulchellum*
32	7-18-69	Riffle Creek	Huttonsville, WV	H	*rubromaculatum* (No *Stenonema* below mine drainage area)
33	7-20-69	Glady Fork	Glady, WV	H	*rubromaculatum, vicarium*
34	7-20-69	Laural Fork	Beaver Dam R. S., WV	H	*rubromaculatum*
35	7-21-69	Cheat River	Rowlesburg, WV	H	*rubromaculatum*
36	7-22-69	East Br. West Clarion River	West of Wilcox, PA	H	*rubromaculatum*
37	7-22-69	Hitchcock Creek	S. of Cherry Grove, PA	H	*rubromaculatum, gildersleevei?, interpunctatum*
38	7-23-69	Marvin Creek	Marvindale, PA	H	*pudicum*
39	7-23-69	Chapman Creek	South of Clarendon, PA	H	*rubromaculatum*
40	7-24-69	Jackson Run	North Warren, PA	H	*rubromaculatum*
41	7-21-69	Laurel Run	Bruceton Mills, WV	N	*interpunctatum*
42	8- 4-69	Big Blue Creek	Shelbyville, IN	H	*interpunctatum, terminatum*
43	8- 4-69	Wildcat Creek	Prymont, IN	N Enriched	*interpunctatum* (2 ssp.), *terminatum, quinquespinum*
44	8- 4-69	Wildcat Creek	Rossville, IN	PH 8.0 H TDS 330	*interpunctatum* (2 ssp.), *pulchellum*
45	7-23-69	Minister Creek	South of Sheffield, PA	H, N	*pudicum*
46	7-24-69	Oswego Creek	Millport, PA	PH 7.2 H TDS 90	*rubromaculatum*
47	7-24-69	Allegheny River	East of Coudersport, PA	H	*vicarium*
48	8- 4-69	Wildcat Creek	Monitor, IN	PH 8.0 H TDS 500	*pulchellum*
49	8- 5-69	Wabash River	Lockport, IN	PH 8.5 H TDS 500 rain swollen	*pulchellum, interpunctatum, quinquespinum*
50	8- 5-69	Wildcat Creek	Jerome, IN	water cloudy	*rubrum, interpunctatum*
51	8- 5-69	Mississinewa River	Matthew, IN	PH 8.5, TDS 800 poll. evident	*pulchellum*

TABLE 4. *STENONEMA* COLLECTING SITES IN THE OHIO RIVER BASIN — Continued

(Site numbers are keyed on Figure 1, a map of the region.)

Site no.	Date	Stream	Location	Notes[1]	Species collected
52	8- 5-69	Wabash River	Markle, IN	PH 8.5 H TDS 580 below pollution source	*pulchellum*
53	8- 6-69	Big Walnut Creek	Greencastle, IN	PH 8.0 H TDS 300	*pulchellum, nepotellum*
54	9-17-69	Mad River	West Liberty, OH	PH 8.0 H TDS 255	*vicarium, pulchellum*
55	9-17-69	Great Miami River	Sidney, OH	PH 8.0 H TDS 300	*pulchellum*
56	9-24-69	Cumberland River	Cumberland Falls, KY	H	*pulchellum, metriotes?, interpunctatum* (ssp. *frontale*)
57	8- 5-69	Eel River	South Whitley, IN	PH 8.0 H TDS 500	*interpunctatum* (ssp. *heterotarsale*)
58	8- 5-69	Tippecanoe River	Warsaw, IN	H	*interpunctatum* (2 ssp.)
59	8- 6-69	Sugar Creek	Crawfordsville, IN	PH 8.0 H TDS 385	*interpunctatum*
60	9-17-69	Stillwater River	Beamsville, OH	H	*interpunctatum, tripunctatum*
61	10- 6-69 3-19-70	Turkey Run Creek	Friendship, OH	H	*scitulum, pulchellum, tripunctatum, vicarium, fuscum*
62	8-13-69	Little Kentucky River	West of Carrolton, KY	H	*scitulum*
63	8-13-69	North Fork of Rough River	Axtel, KY	H	*tripunctatum, scitulum*
64	*10-21-65	Sugar Creek	Amity, IN	H	*interpunctatum, tripunctatum*
65	*10-11-66	Mississinewa River	Peru, IN	B	*interpunctatum, pulchellum*
66	*10-22-65 5- 6-70	Sand Creek	Reddington, IN	B	*interpunctatum, scitulum, pulchellum, ares, rubromaculatum, carolina, tripunctatum*
67	*10-26-66	Vermilion River	Bismark, IL	B	*interpunctatum, tripunctatum*
68	*10-14-65	White River	Newberry, IN	B	*interpunctatum, integrum, ares*
69	*10-27-66	Little Vermilion River	Sidell, IL	B	*rubrum, interpunctatum, pulchellum, tripunctatum, nepotellum*
70	*5-23-67	Vermilion River	Danville, IL	B	*interpunctatum, pulchellum, quinquespinum*
71	*8-24-67	Riley Creek	Charleston, IL	B	*interpunctatum*
72	*8-24-67	Kickapoo Creek	Charleston, IL	H	*interpunctatum*
73	*9-22-66	Kokomo Creek	Kokomo, IL	B	*interpunctatum*
74	*10-12-65	Big Duck Creek	Northeast of Noblesville, IN	H	*interpunctatum, tripunctatum*
75	*8-24-67	Embarras River	Charleston, IL	H	*interpunctatum, scitulum*
76	*11- 9-67	Tradewater River	St. Charles, KY	B	*interpunctatum*
77	*10-13-65	Little Eagle Creek	Indianapolis, IN	H	*tripunctatum*
78	*11- 3-67	Wiley Creek	Princeton, KY	H	*scitulum*
79	*11- 1-67	Slover Creek	Providence, KY	H	*scitulum*
80	*10-27-67	Tradewater River	Kelly, KY	B	*scitulum, interpunctatum*
81	*11- 1-67	Greasy Creek	Madisonville, IN	H	*tripunctatum*

TABLE 4. *STENONEMA* COLLECTING SITES IN THE OHIO RIVER BASIN — Continued

(Site numbers are keyed on Figure 1, a map of the region.)

Site no.	Date	Stream	Location	Notes[1]	Species collected
82	*10-13-66	Coal Creek	Veedersburg, IN	H	*pudicum?, pulchellum*
83	*10-13-65	Middle Fork of Vermilion River	Penfield, IL	H	*ares, rubrum*
84	*4-18-67	White River	Petersburg, IN	B	*rubrum, pulchellum, terminatum*
85	*8- 3-67	Little Kanawha River	Palestine, WV	S	*interpunctatum*
86	*6- 3-38	Beargrass Creek	Louisville, KY	H	*interpunctatum*
87	*5-22-42	Salt Fork River	Oakwood, IL	H	*interpunctatum*
88	*5-10-46	Wabash River	Grayville, IN	B	*interpunctatum*
89	8-28-69	Ohio River	Ironton, OH	B	*interpunctatum*
90	*6- 7-46	Lusk Creek	Eddyville, IL	H	*candidum*
91	*10- 7-67	Little Kanawha River	Glenville, WV	S	*tripunctatum*
92	7- 1-70	Twelve Mile Creek	Monroe Township, OH	H	*femoratum*
93	*10- 8-64	Reedy Creek	Palestine, WV	S	*luteum?*
94	*4-17-46	Muddy Creek	Jewett, IL	H	*ares*
95	8-25-69	Ohio River	Markland Dam, KY	B	*pulchellum, integrum*
96	*9- 5-67	Ohio River	Evansville, IN	B	*integrum*
97	7-24-68	Ohio River	Meldahl Dam, OH	B	*integrum*
98	9-12-68	Ohio River	Portsmouth, OH	B	*integrum, terminatum*
99	6-16-70	Ohio River	Pittsburg, PA	B	*integrum*
100	8-29-69	Scioto River	Lucasville, OH	B	*terminatum, exiguum*

[1] Symbols
*Not collected by the author.
B, collected by basket sampler.
H, collected by hand from rocks and vegetation.
G, collected by grab.
S, collected by Surber sampler.
N, collected by net.
M, collected by multiplate sampler.

APPENDIX C — DISTRIBUTION MAPS

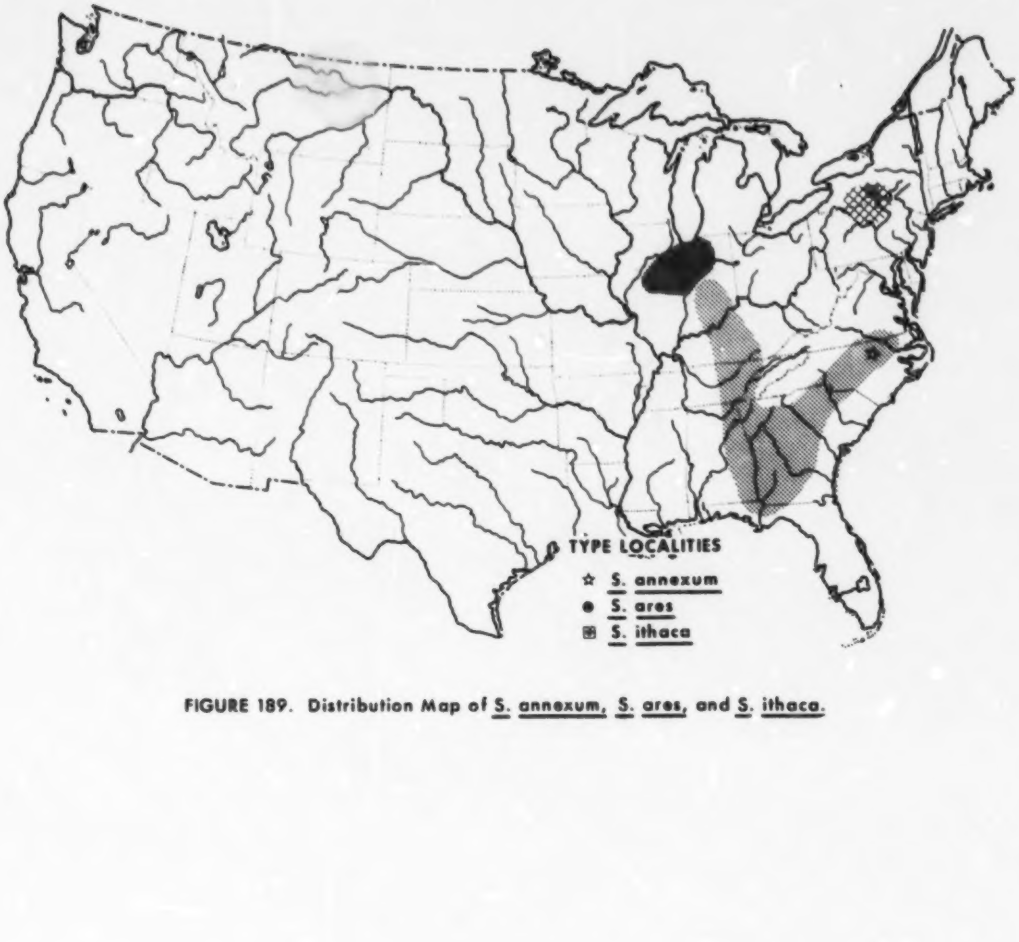
TYPE LOCALITIES
☆ S. annexum
● S. ares
▦ S. ithaca

FIGURE 189. Distribution Map of S. annexum, S. ares, and S. ithaca.

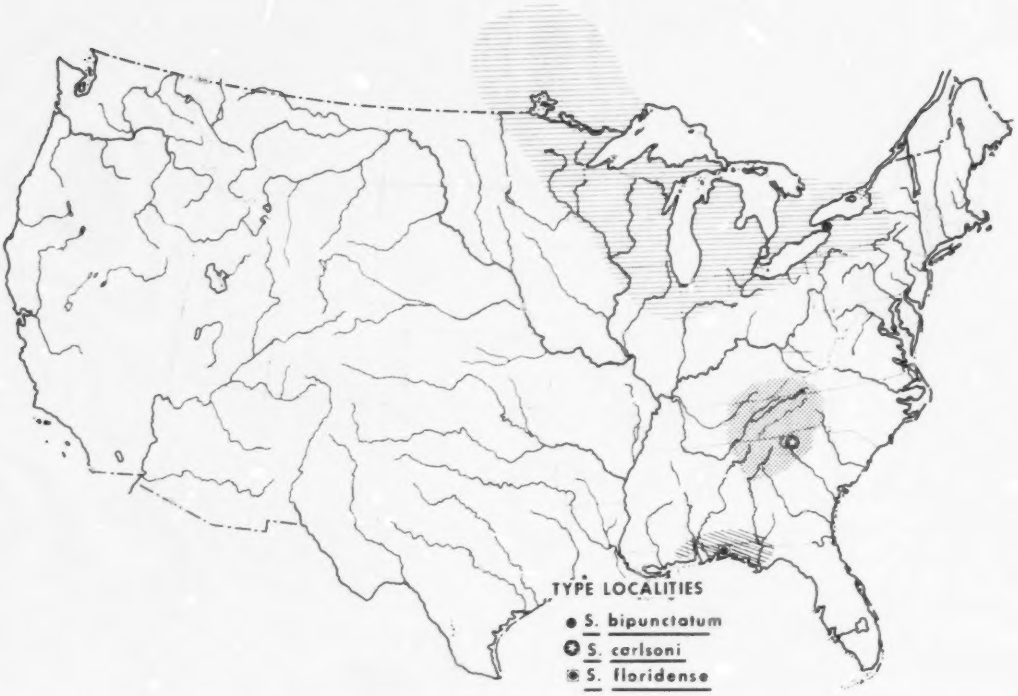
TYPE LOCALITIES
● S. bipunctatum
○ S. carlsoni
✱ S. floridense

FIGURE 190. Distribution Map of S. bipunctatum, S. carlsoni, and S. floridense.

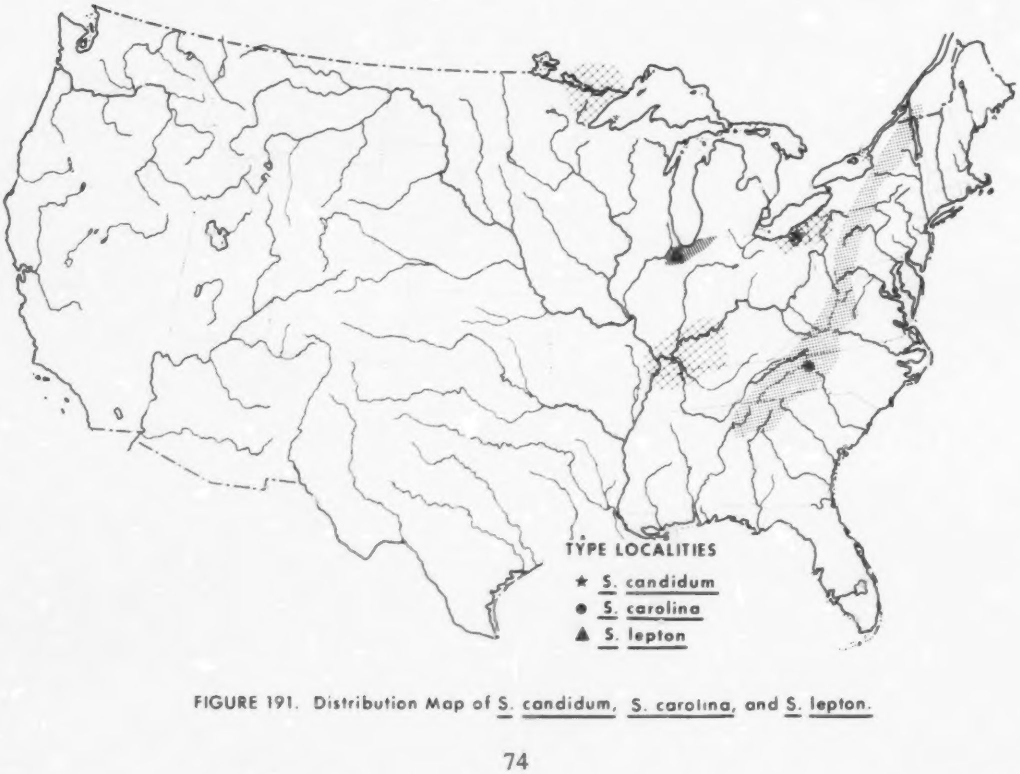
TYPE LOCALITIES
★ S. candidum
● S. carolina
▲ S. lepton

FIGURE 191. Distribution Map of S. candidum, S. carolina, and S. lepton.

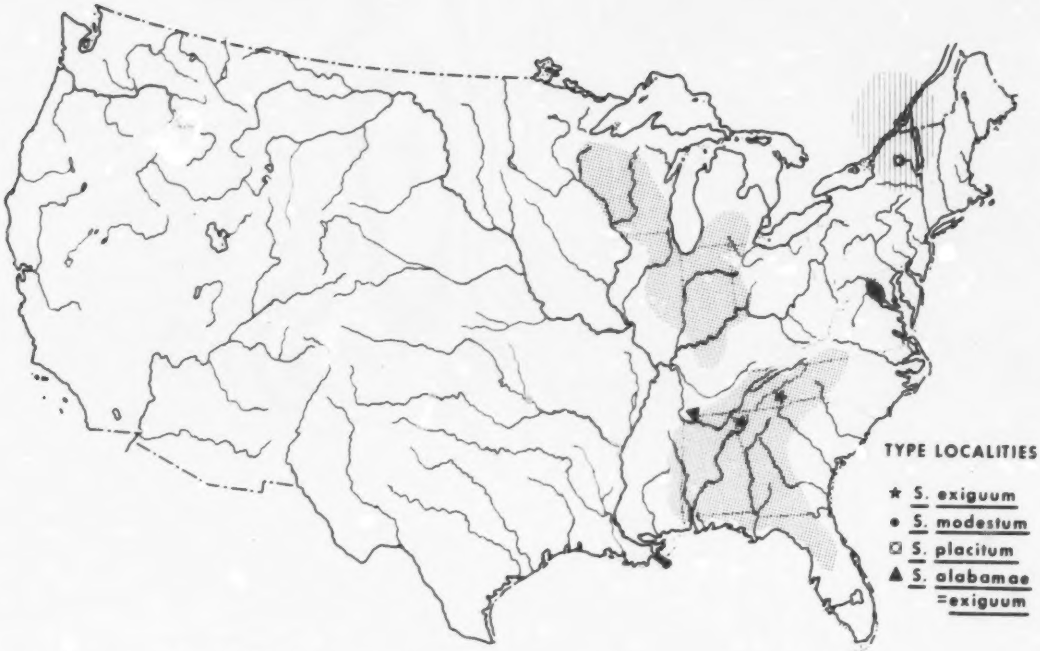
TYPE LOCALITIES
★ S. exiguum
● S. modestum
□ S. placitum
▲ S. alabamae =exiguum

FIGURE 192. Distribution Map of S. exiguum, S. modestum, and S. placitum.

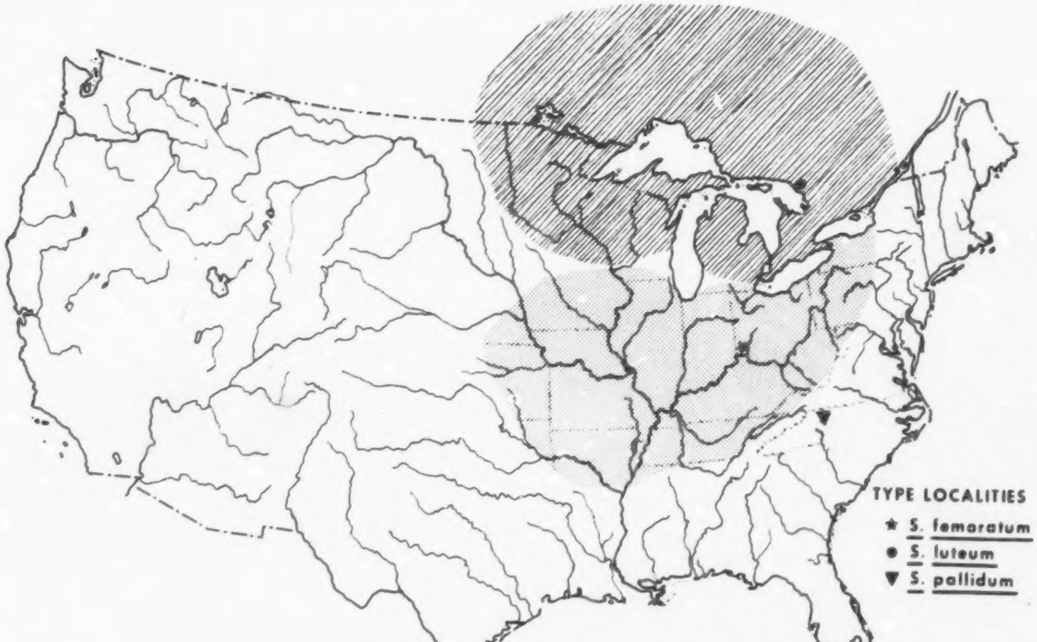
TYPE LOCALITIES
★ S. femoratum
● S. luteum
▼ S. pallidum

FIGURE 193. Distribution Map of S. femoratum, S. luteum, and S. pallidum.

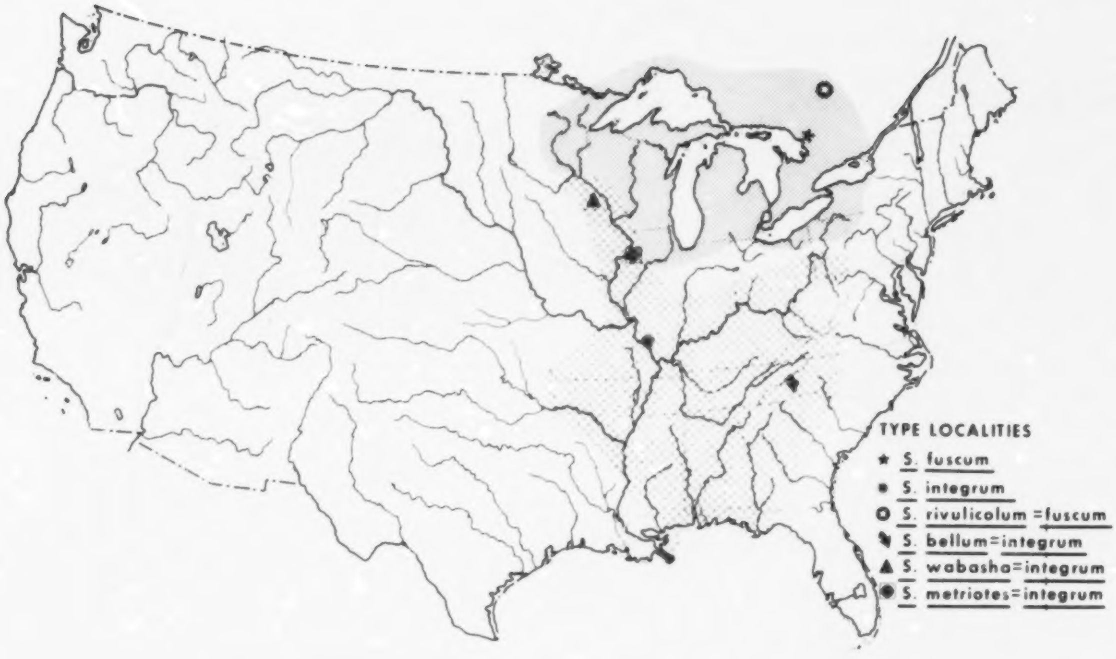
TYPE LOCALITIES
★ S. fuscum
● S. integrum
○ S. rivulicolum =fuscum
◆ S. bellum=integrum
▲ S. wabasha=integrum
● S. metriotes=integrum

FIGURE 194. Distribution Map for *S. fuscum* and *S. integrum*.

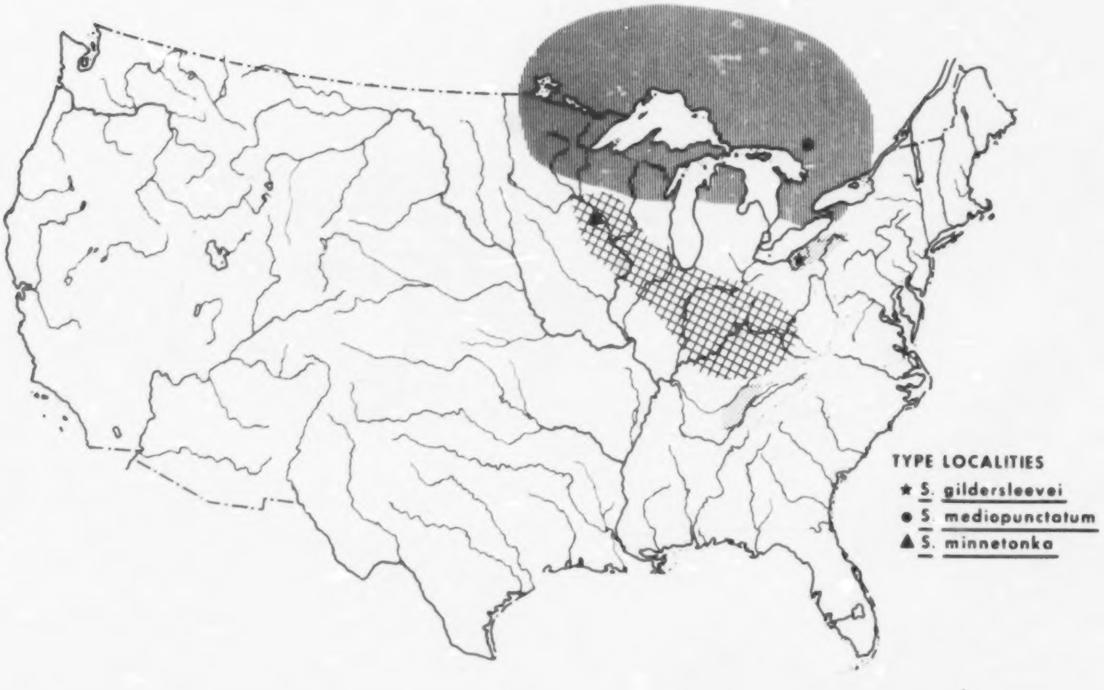
TYPE LOCALITIES
★ S. gildersleevei
● S. mediopunctatum
▲ S. minnetonka

FIGURE 195. Distribution Map of *S. gildersleevei*, *S. mediopunctatum*, and *S. minnetonka*.

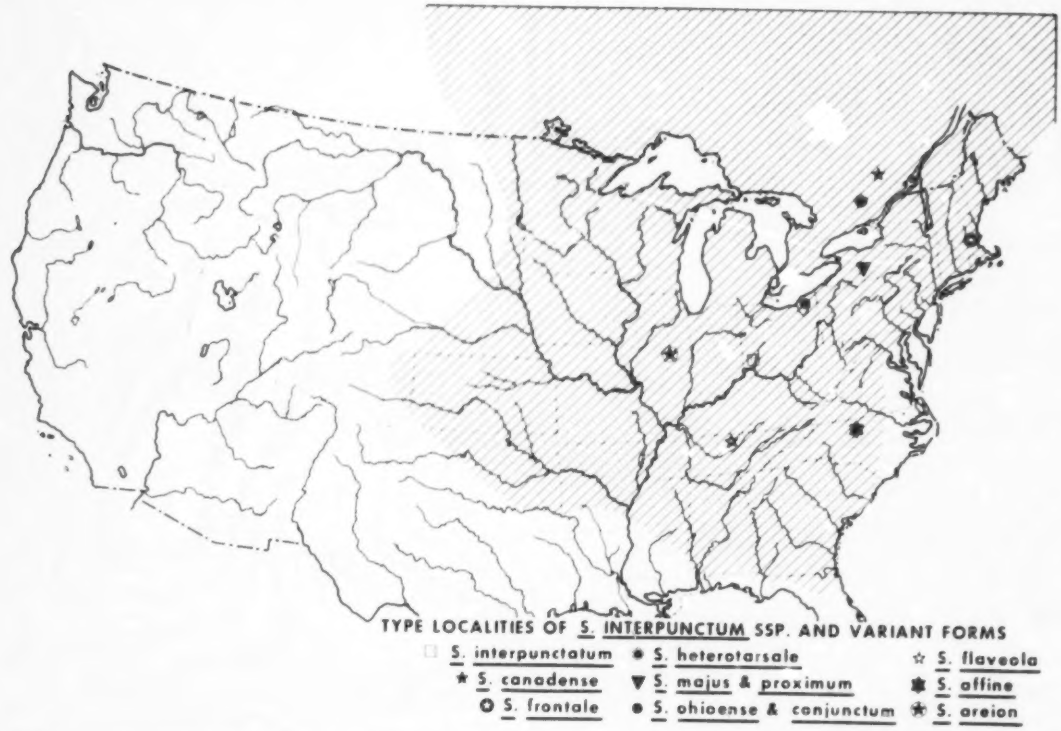
TYPE LOCALITIES OF S. INTERPUNCTUM SSP. AND VARIANT FORMS
□ S. interpunctatum
✱ S. heterotarsale
☆ S. flaveola
★ S. canadense
▼ S. majus & proximum
✸ S. affine
○ S. frontale
● S. ohioense & conjunctum
✶ S. areion

FIGURE 196. Distribution Map of S. interpunctatum Including Type Localities of Variant Forms.

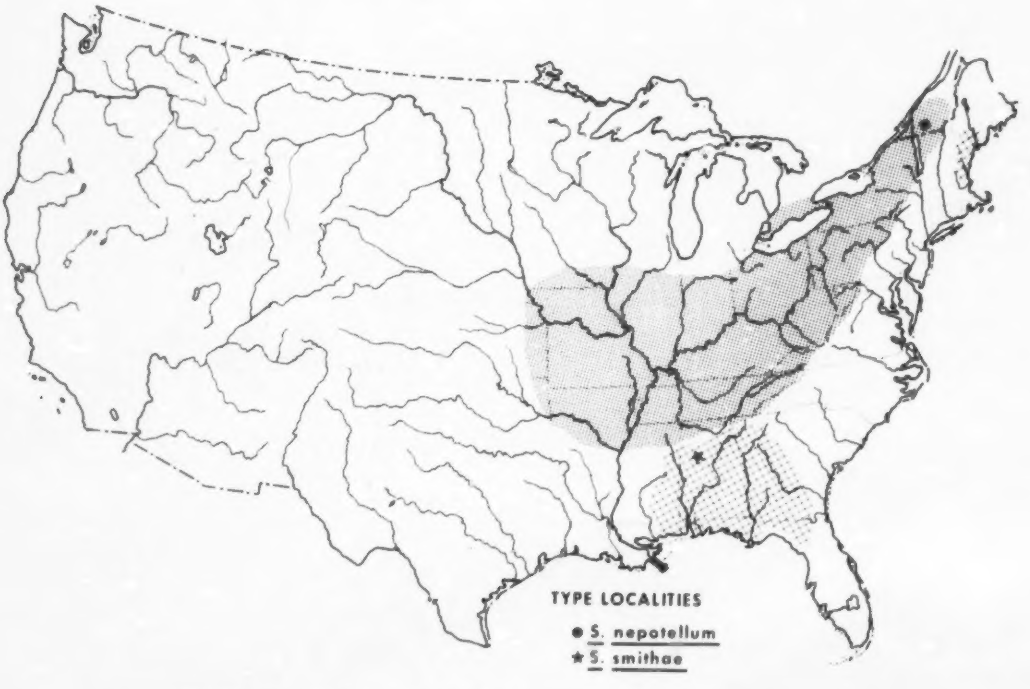
TYPE LOCALITIES
● S. nepotellum
★ S. smithae

FIGURE 197. Distribution Map of S. nepotellum and S. smithae.

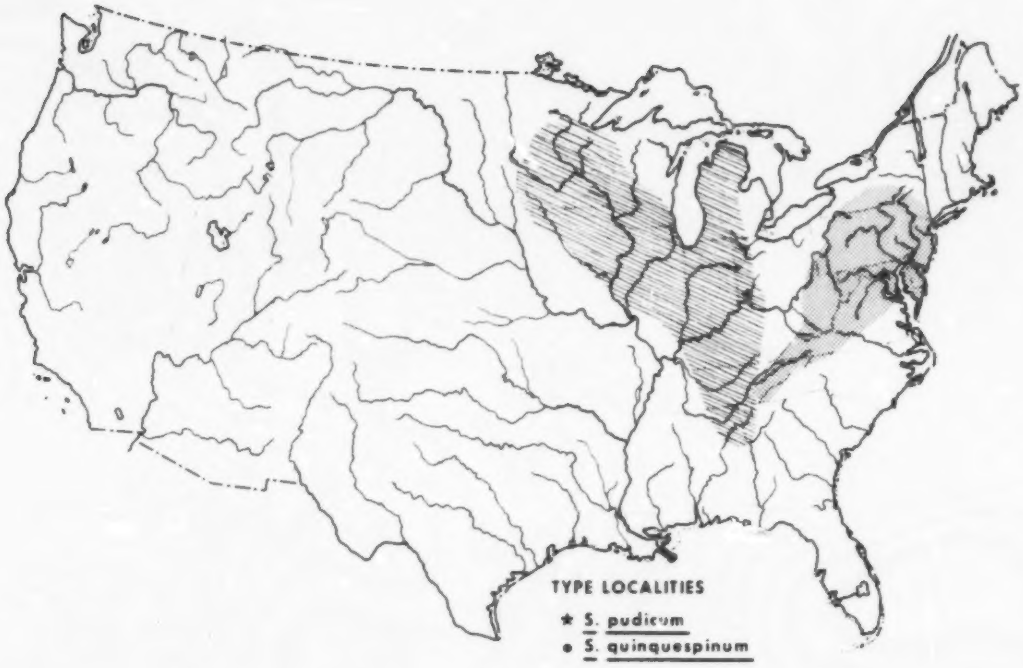
TYPE LOCALITIES
★ S. pudicum
● S. quinquespinum

FIGURE 198. Distribution Map of S. pudicum and S. quinquespinum.

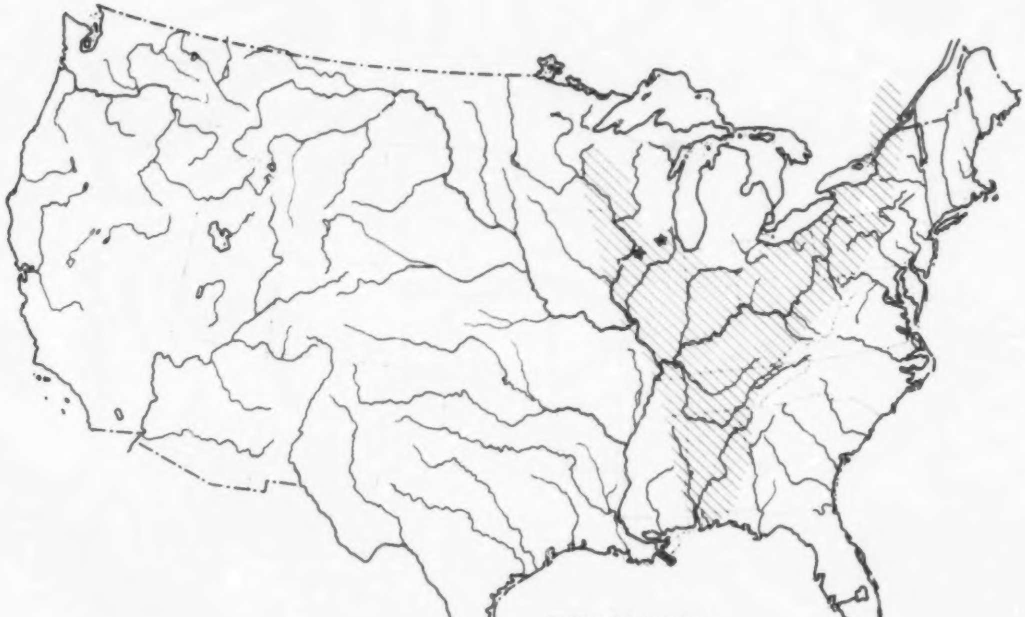
TYPE LOCALITIES
★ S. pulchellum

FIGURE 199. Distribution Map of S. pulchellum.

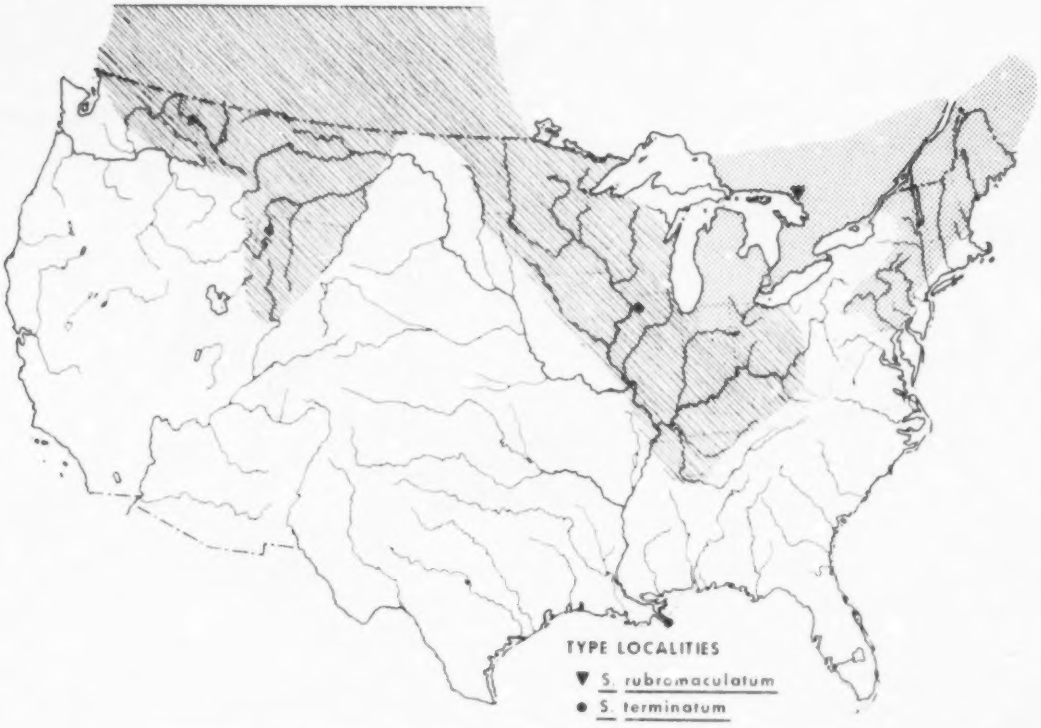
TYPE LOCALITIES
▼ S. rubromaculatum
● S. terminatum

FIGURE 200. Distribution Map of S. rubromaculatum and S. terminatum.

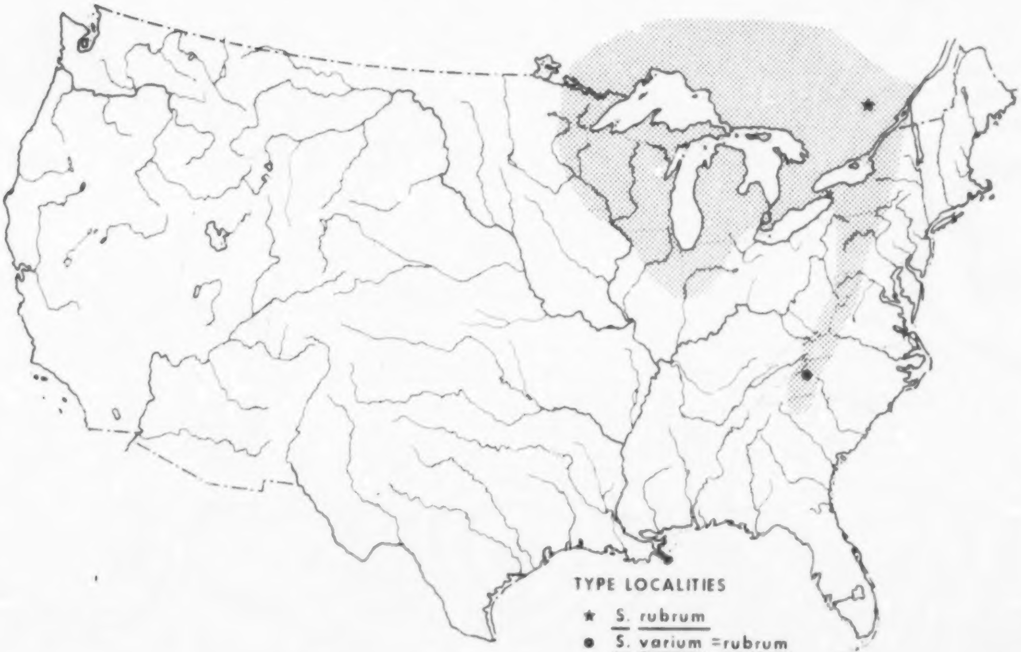
TYPE LOCALITIES
★ S. rubrum
● S. varium =rubrum

FIGURE 201. Distribution Map of S. rubrum.

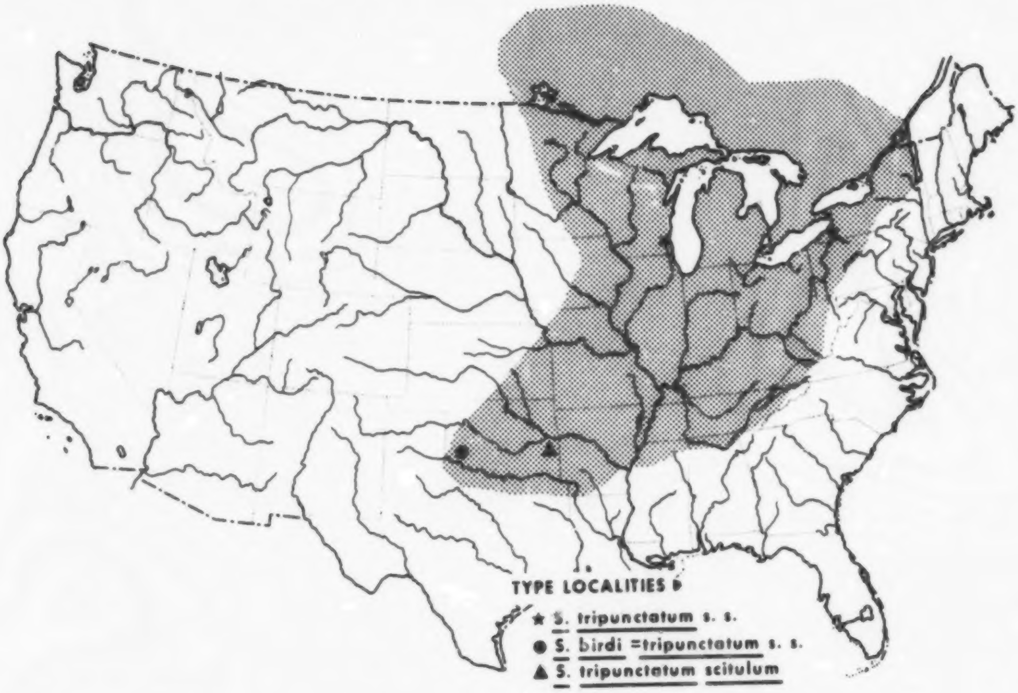
TYPE LOCALITIES
★ S. tripunctatum s. s.
● S. birdi =tripunctatum s. s.
▲ S. tripunctatum scitulum

FIGURE 202. Distribution Map of *S. tripunctatum* Including Variant Forms.

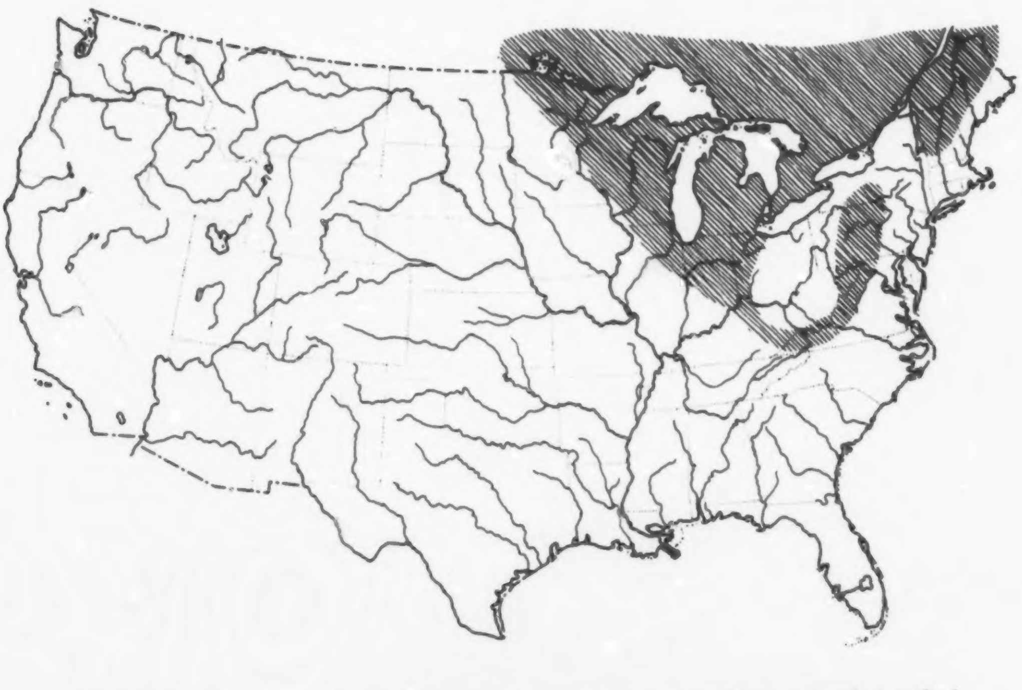

FIGURE 203. Distribution Map of *S. vicarium* (Type locality somewhere in North America).